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PROCEEDINGS OF THE WORKSHOP ON SOYBEANS FOR TROPICAL AND SUBTROPICAL CONDITIONS

February 4-6, 1974
University of Puerto Rico
Mayagüez Campus

Sponsored by the International Soybean Program--INTSOY, a cooperative program of the University of Puerto Rico, Mayaguez Campus, and the University of Illinois at Urbana-Champaign, with the support of the U.S. Agency for International Development.

International Soybean Program
INTSOY

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COLLEGE OF AGRICULTURE / UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Copies of this report may be obtained from International Soybean Program --INTSOY -- at either University of Puerto Rico, College of Agricultural Sciences, Mayaguez, Puerto Rico, or University of Illinois, College of Agriculture, 113 Mumford Hall, Urbana, Illinois 61801.

(Se puede obtener copias de este informe del Programa Internacional de la Soja -- INTSOY -- en cualquier de sus sucursales: la Universidad de Puerto Rico, Facultad de Ciencias Agriculturales, Mayaguez, Puerto Rico, o en University of Illinois, College of Agriculture, 113 Mumford Hall, Urbana, Illinois 61801.)

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RESOLUTION TO

Dean Salvador E. Alemañy and his colleagues
From the Workshop on Soybeans for Tropical and Subtropical Conditions
University of Puerto Rico, Mayaguez Campus - 1974 February 4-6

WHEREAS: Within recent years there is increasing interest among developing countries in the tropics and subtropics in the production of protein sources particularly soya. . . . .

WHEREAS: There is need for increased communications and exchanges of information between individuals among all countries dealing with research and technology of soybean production and utilization in the tropics and subtropics: and. . . . .

WHEREAS: The workshop was a recognition and effort to deal with these needs;

BE IT RESOLVED, that all delegates representing commercial, and technical from North, Central, and South America, the Caribbean, and Asia and International Agencies wish to thank UNIVERSITY OF PUERTO RICO; UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT and the UNIVERSITY OF ILLINOIS, and the INTSOY group for their leadership in organizing the workshop; with special thanks to UNIVERSITY OF PUERTO RICO for its generous and gracious hospitality particularly, Dean Salvador E. Alemañy, Dr. Raúl Abrams and Dr. Bernardino Rodríguez-López; thanks should also be extended to United States Agency for International Development for their encouragement and financial support.

Respectfully Submitted,

RESOLUTION COMMITTEE:

Christian - C - Nwasike
Central Agricultural Station
Non Repos - Guyana

Lawrence Cross
Ministry of Agriculture
Trinidad and Tobago
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CONTENTS

THE TASK AHEAD

Salvador E. Alemañy 1/

The task that we are about to engage in today is highly significant in several of its aspects. First of all, it represents a joint effort between two Institutions of Higher Learning, both of which honor the spirit and the purpose of the University in its essential mission. The University of Illinois has a long and distinguished history in the field of soybean research, in a state that has become the heart of the world's greatest soybean-producing center. In turn, the University of Puerto Rico has an important role to play in tropical agriculture and, besides, is the only Spanish speaking Land-Grant University. Because of the very nature of our two Institutions this joint endeavor represents more than just an intellectual exchange in a specific area of knowledge.

Secondly, in a true University tradition, the talents and experiences of scientists and scholars from all over the world are pooled together in an effort to procure solutions to some of the pressing problems that we face today.

Third, the subject of the meeting is a crop of great potential- soybeans- which offers a promising solution to the serious challenge of feeding the world population, a high proportion of which right now suffers from hunger and malnutrition. There are few problems, if any facing mankind today, which appear more difficult and complex. The problem is worst, precisely where the potential is greatest, in the Tropics. But this happens to be the place in which we live and it becomes increasingly difficult to remain aloof in the face of such a challenge.

A few additional facts may well serve to dramatize the importance of the task we are facing right here today, and to establish a proper

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1/ Dean, College of Agricultural Sciences, Mayaguez Campus of the University of Puerto Rico.

2/ Robert, L. M., The Food Legumes Recommendations for Expansion and Accéleration of Research, Nov. 10, 1970. (Mimeographed).

3/ Ibid., p. 3.

framework for action. Approximately two-thirds of the world's population now live in the Tropical Belt, and worst yet, the predictions are for further relative and absolute increases in the future. 2/

It is precisely in the Tropics where human diets are most deficient in proteins, and it is not necessary to remind you of the irreversible physical and mental damages brought about by these deficiencies.

The "Green Revolution" did a splendid job in providing new varieties of crops for feeding the world's population, although its main contribution has been in the field of starchy crops. Unfortunately, the latter have done little to relieve this serious situation.

Soybeans appear to be the answer to that problem. This is possibly the best choice among other alternatives to accomplish this end. Its high quality protein content is nearly 40 percent. Its adoption by many countries seems like a most adequate endeavor to complement the great achievements of the "Green Revolution" with a "Protein Thrust." If you wish one may coin a new slogan to combine the two concepts: "Vegetable Protein Thrust." It must be remembered that about 70 percent of the protein in the human diet, worldwide comes from vegetable sources and 30 percent from animal sources.

Therefore, our workshop on Soybeans for Tropical and Subtropical Conditions acquires a worldwide significance. The job is highly complex. It calls for a concerted international effort of the best institutions and the best minds. For obvious reasons no other institution fits the task better than the University. To that end, proposals have been drafted by the University of Illinois and the University of Puerto Rico to join talents and efforts in the development of an International Soybean Resource Base. The Resource Base is a new concept which functions similarly to such international centers as the International Rice Research Institute (IRRI) and the International Maize and Wheat Center in Mexico. (CIMMYT).

It is in this context and in this spirit, my friends, that we at the University of Puerto Rico welcome the opportunity to collaborate with the University of Illinois, with US-AID, and with you personally and the countries you represent. We want to respond "present" to the "Challenge of growth," the "Challenge of Excellence," "Challenge of service" and the "Challenge of survival."

Thank you,

TALK IS NOT JUST TALK

George K. Brinegar 1/

Technical assistance in contrast to capital assistance or disaster relief is talk. Higher education is talk, it is not muted behavior. To quote a quote from Ogden Nash:

> "Sticks and stones may break my bones but words can break my heart."

We have gathered on this occasion to engage in the best of talk about a program, the International Soybean Program (INTSOY), that holds promise of generating talk over the next 10 or 20 years that history will evaluate as one that made a difference in the quality of life in terms of nutrition and all it implies; in demonstrating an efficient institutional model drawing on the best from higher education and technical assistance agencies to accomplish complex and significant goals, and to increase and strengthen the competence of universities, technical assistance agencies and their personnel; all with the side benefits of increasing and improving international understanding and cooperation which flows from meaningful interaction and communication.

Talk of the above sort may sound like puffery when we remind ourselves that talk, like money, follows Gresham's law--the bad drives out the good. At this point in history the inflation in talk, or in money terms the debasement of the currency, is reaching new highs on the decibel scale. The new highs in inflated talk seems to be international and cross-cultural and most of it devoted to the depreciation of one's self and associates. Moreover, the self-depreciation is not only the past time of the leisure class but the profession of many self-appointed defenders of fundamental virtue. The universities and technical assistance agencies have also queued up with eagerness to engage in self flagellation as part of the riutal of self-depreciation. I quote first from <u>Focus, Technical Cooperation:</u>

"Something is wrong." There is a great deal of evidence in this issue of Focus that something is wrong with the technical assistance business as it is now practiced. "Something is wrong--see Hall and

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1/ Director, International Programs and Studies, University of Illinois at Urbana-Champaign.

Dieffenbach.... See Helleiner and Pratt.... See Globerson.... Beyond these, something is fundamentally wrong. . . ."

May I now shift from AID to the Carnegie Report on higher education which states:

(1) A "new depression" has set in.

(2) "Higher education has not yet made up its collective mind about how it should and will conduct itself vis-a-vis the political arena, and it remains to be seen whether it will want to make up its mind and be able to do so";

(3) "Finally, confidence in higher education has eroded recently, according to the Commission. 'A traumatic loss of a sense of assured progress, of the inevitability of a better future, has occurred,' the Commission said. 'The prevalent attitude is more to look back with longing than to look ahead with hope."

Thus, it may seem strange to be out of step with the times, to defy the law of inflation in the currency of talk. So we ask why is the joint enterprise we call INTSOY, involving AID, the University of Puerto Rico and the University of Illinois as partners and potentially excluding no others as partners, so extremely attractive? I hope my comments will show there is no mystery in why INTSOY should be alive and well in this period of self flagellation.

INTSOY is pointed toward an exciting important humanitarian goal, that of increasing the consumption by people of high quality, low cost protein and other food. However, a noble goal is not enough, the roads to hell are paved with good intentions. If a "big problem" is to be exciting and meaningful, and other than puffery, it must be divisible into many manageable small problems, from which feedback flows indicating successes and failures and next steps to take. INTSOY meets the feedback test, and perhaps all the more remarkable, because the program involves learners and teachers with each actor being both; involves the physical and biological sciences, as well as the humanities and social sciences. Additionally, the common problem on which INTSOY focuses crosses all cultures, geographical areas, income groups, etc.

The richness of INTSOY is also increased because it is not only a new institution based on a new concept but it is a growing concept and institution which may have applicability to the solution of other important problems of people. For example, the structure of INTSOY is a viable solution to the problem of establishing effective cooperation

among, and linkages between and among all the actors and contributers to what we call human progress. Thus, the INTSOY model is conceived in the concept of hope, but it is more than hope, since it is operational, manageable and points where we want to go.

It is not enough for a program to be in some sense "do good" to others--a viable program must also have much to offer the institutional actors and to each of the individuals within each of the institutions. The gains of the actors, institutional and individual, will be highly correlated with the extent of the involvement by each institution and individual. May I therefore urge each of us, present or absent from this session, to get into the act. We at the University of Illinois expect to gain much from each of you. We hope each of you will gain from us.

Programs of the INTSOY type also serve more general purposes and goals which, for want of more adequate verbalization, are called improving cross-cultural and international understanding and cooperation, which flows from meaningful collaboration over extended periods of time. We at the University of Illinois, as a partner is this program, expect to learn much from many groups, from many places, in many fields of study with a result that can only make us better scholars and human beings.

May I conclude by saying thank you to President Morales Carrion, Dean Alemañy and the University of Puerto Rico for hosting this session. May I extend our welcome to you and your staff to come to the University of Illinois--we highly value working with you.

OPENING SESSION of the WORKSHOP on SOYBEAN for TROPICAL and SUBTROPICAL PRODUCTION

Mr. G. K. Parman 1/

President Morales Carrión, Dean Alemañy, distinguished guests, and Gentlemen. I bring the greetings of Mr. Parker, the Administrator of AID; of Dr. Bernstein, Head of the Technical Assistance Bureau; of Dr. O. J. Kelley, Director of the Office of Agriculture and of my own Chief, Dr. Sam Litzenberger, whom so many of you know and respect.

AID is pleased to see this Workshop become a reality. It accents our concern in developing outreach activities and in encouraging the formation of research networks to bind together research workers and research stations throughout the world in a common attack on the problem of world hunger. The challenges which face us are being rapidly exacerbated by the mounting costs of fertilizer and agricultural chemicals. Fertilizer prices have increased three fold; agricultural chemicals such as pesticides have doubled in price. It will be increasingly difficult for the small farmer, and many large farmers, in the LDCs to use, or even purchase these inputs. We must begin to seek for maximum production from minimum inputs. The soybean is, of course, of interest because it generates its own nitrogenous fertilizer and leaves a generous bonus for the next crop, but we must still contend with disease and insect pests. This will be a challenge to all of us and one that should be borne in mind as we begin this workshop.

From a personal viewpoint, I am looking forward with pleasure, to the papers and the discussions of the experts here assembled.

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1 Specialist Food Processing, Office of Agriculture Bureau of Technical Assistance, USAID, Washington, D. C.

THE INTERNATIONAL SOYBEAN PROGRAM-INTSOY

Carl N. Hittle 1/

Durante los últimos siete u ocho años la Universidad de Illinois ha estado asociada en el programa de investigación para la producción de soyas en la India. Este programa ha sido coordinado y programado desde el punto de vista de trabajo en equipo de profesionales. Recientemente US-AID y otras universidades han estado participando en este programa. Este proyecto ha servido de modelo para una investigación coordinada intra e inter-institucional. El programa internacional de soyas está siendo desarrollado para servir a las necesidades de países en desarrollo. La necesidad de este programa surje por la gran deficiencia de calorías y proteínas que existe en una gran parte de la población mundial y del gran potencial de la habichuela soya que contiene un cuarenta por ciento de proteína y un veinte por ciento de aceite. El programa internacional de soyas (INTSOY) está concernido con todos los aspectos de las soyas, desde la siembra, cosecha, mercadeo, procesamiento y usos. El mayor énfasis se le está dando al potencial único de la soya como fuente de proteína para el consumo humano en las regiones tropicales y subtropicales del mundo. Se presentan datos de los resultados ontenidos en India.

The University of Illinois has a long tradition of vigorous soybean programs. It has been involved in soybean research and utilization since the crop was first introduced into Illinois before the turn of the century. Close cooperative working relationships have been developed with the USDA Northern Regional Research Laboratory at Peoria, Illinois, and the U.S. Regional Soybean Laboratory on the Urbana campus of the University. There are numerous other close professional ties with other universities and other agencies.

In this discussion I will not deal with the details of the activities, interests and competencies of the University of Illinois and the cooperating agencies. This was adequately covered in the meeting of the INTSOY Steering Committee held on July 9-10, 1973 at the University of Illinois. The Proceedings are available to anyone desiring a copy.

1/ Professor of Plant Breeding, University of Illinois

The University of Illinois has been involved in "things international" since the University was founded. During the mid-sixties the University developed a research program in production and utilization of soybeans for human consumption, as a part of its institutional development programs in India. Those programs were interinstitutional and interdisciplinary in nature. Interest in a soybean resource base on a worldwide basis is an outgrowth of the very encouraging results of those programs.

The approach, the problems and the accomplishments of those programs will be illustrated with a few examples from the area of production research.

For the past 7 or 8 years, several University of Illinois agronomists have been associated with the soybean production research program in India, which was part of the university development programs. The coordinated Research Project of Soybeans, in every sense, emphasized the team approach. To begin with, it was a joint venture of the Indian Council of Agricultural Research (ICAR), the G. B. Pant University of Agriculture and Technology (Pantnagar, U. P., India), the Jawaharlal Nehru Agricultural University (Jabalpur, M. P., India), USAID and the University of Illinois with assistance from the Ministry of Agriculture, Government of India. More recently the state departments of agriculture, many additional universities and various other organizations have entered into this cooperative program. Coordination of research, teaching and extension has been, and is considered essential in order for the project to have an impact on Indian agriculture.

This project has also provided a working model for coordinated intra-and inter-institutional research. Plant breeders, agronomists, botanists, pathologists, entomologists, microbiologists, agricultural economists, and extension workers are concerned with producing the crop and getting it to the consumer. Efforts by food technologists, food processors, industrial engineers and home economists are directed at insuring that soybeans and soybean products will find a place in the Indian diet.

The results of the Indian program have been very encouraging. The performance of a few of the soybean varieties evaluated in experimental plots in central India is shown in Table I. The better performing varieties are those from the Gulf Coastal States of the U. S., i. e., the Southern varieties.

Table 1. Performance of Several Soybean Varieties Evaluated During the Monsoon Seasons at Jawaharlal Nehru Agricultural University, Jabalpur, India.

Variety*	Maturity Group	Yield: Quintals† per Hectare 4-Yr. Ave. 1968-1971	Quintals† per Hectare 5-Yr. Ave. 1967-1971	Bushels per Acre 4-Yr. Ave. 1968-1971	Bushels per Acre 5-Yr. Ave. 1967-1971
Bragg	VII	33.1	31.6	49.6	47.4
Semmes	VII	31.7	--	47.5	--
Davis	VI	31.5	--	47.2	--
Lee	VI	29.5	28.7	44.2	43.0
Hood	VI	28.0	27.4	42.0	41.1
Pb-1	--	27.9	--	41.8	--
Clark 63	IV	22.0	22.1	33.0	33.1

*All varieties are introductions from the United States except Pb-1 which is an Indian selection.

†One quintal = 100 kg.

In 1971 many on-farm demonstration plantings were grown throughout the state of Madhya Pradesh. Each planting was one acre in size. As indicated in Table 2, yields from 42 of the plantings varied from 10 to 38 quintals per hectare or 15 to 57 bushels per acre. Thus the better yields obtained from demonstration plantings were comparable to those obtained at the experiment station, Jabalpur. The results indicate the yield potential, for the cultivator, when strict attention is paid to all steps of "The Package of Practices."

Table 2. Soybean Yields Obtained from Demonstration Plantings of Bragg Variety Throughout the State of Madhya Pradesh, India, 1971.

District	Number of Plantings	Yield: Quintals* per Hectare Range	Quintals* per Hectare Ave.	Bushels per Acre Range	Bushels per Acre Ave.
Seoni	14	11.8-38.0	24.2	17.7-57.0	36.3
Senore	18	9.9-26.7	20.8	14.8-40.0	31.2
Indore	10	15.6-19.5	17.5	23.4-29.2	26.2

*One quintal = 100 kg.

In central India, yields of plots inoculated with Rhizobium japonicum bacteria have been higher than those of uninoculated plots even with the addition of 120 kg/ha. (108 lb./acre) of nitrogen fertilizer

(Table 3). As shown in Table 4, yields have been doubled by ensuring effective inoculation and nodulation. When soybeans are introduced into new areas it is of vital importance to also introduce highly effective strains of Rhizobium japonicum.

Table 3. Soybean Grain Yields as Influenced by Inoculation and Nitrogen Applications, Bragg Variety, Jawaharlal Nehru Agricultural University, Jabalpur, India.

Nitrogen Fertilizer		Two-Year Averages, 1968-69			
		Quintals* per Hectare		Bushels per Acre	
kg./ha.	lb./acre	Inoculated†	Not Inoculated	Inoculated†	Not Inoculated
0	0	36.4	20.1	54.6	30.1
30	27	36.8	23.0	55.2	34.5
120	108	37.4	27.0	56.1	40.5

*One quintal = 100 kg.
†Inoculated with Nitragin inoculum from United States.

Table 4. Response of Bragg Soybeans to Inoculation Without Nitrogen Fertilization, Jabalpur, India.

Treatment	Yield			
	Quintals* per Hectare		Bushels per Acre	
	1968	1969	1968	1969
Control (uninoculated)	18.6	18.0	27.9	27.0
Nitragin (inoculum from U. S.)	37.5	36.0	56.2	54.0

*One quintal = 100 kg.

Before we leave the subject of Rhizobium japonicum and inoculum, it should be mentioned that a Pilot Research Plant for the Development of Legume Inoculants was put in operation at G. B. Pant University of Agriculture and Technology in India, with the assistance of Dr. Forster Davidson, who was a member of the University of Illinois/USAID contract team from 1971-1973. This plant has been and is of great benefit to India in providing inoculum. It will soon be in a position to offer training to interested personnel from India and other countries.

The illustrations used emphasize production and extension activities in agronomy. Other examples from other disciplines could be

cited. For example, Dr. J. B. Sinclair, who will be discussing bacterial and fungal diseases of soybeans at this Workshop, brought a maturity to the Department of Plant Pathology in the international realm. This was with the assistance of a 211(d) USAID grant for five years, 1968-1973. Five of Dr. Sinclair's M. S. and Ph. D. students from the U. S. completed their course work at the University of Illinois, did their thesis work abroad (either in Nigeria or India) and finally returned to the University of Illinois to write up the research and receive their degrees. He has also had five students from other countries who obtained their degrees at the University of Illinois and returned to their respective country.

When entomologists at the University of Illinois and the Illinois Natural History Survey began looking at soybean insect problems on an international basis, they decided to establish a multidimensional research program. The three major activities of the soybean entomology team are (1) literature collection of soybean arthropods, computerized, (2) international collection of soybean arthropods, computerized, and (3) other research. Dr. George Godfrey and Dr. Marcos Kogan will be discussing some aspects of the entomology program at this Workshop.

Dr. Sheldon W. Williams of the Department of Agricultural Economics assisted the Soybean Research Project in India for three years in areas of marketing, cost of production and acceptance studies of soybean-enriched wheat flour for use in chapatis. He also instigated a "Soybean Marketing Information" newsletter. This newsletter is still being published, is widely distributed in India and is materially assisting the development of the soybean industry.

Professor Al Nelson, of the University of Illinois Food Science Department, has made a major contribution in assisting G. B. Pant University at Pantnagar, India, in setting up a Pilot Research Plant for the Development of Soybean Products. At this Workshop he will be telling you more about this plant and Dr. Les Ferrier will be demonstrating the products developed at the University of Illinois.

Similar international accomplishments of other individuals and departments, including Agricultural Engineering and Home Economics, could also be cited.

So much for the past! Where do we stand now? Just what is INTSOY? What are the objectives of the Program? Where are we going?

The International Soybean Resource Base is being developed to serve the needs of developing countries, much as is now being done by the international centers for other major food crops. These existing

centers include CIMMYT (Centro Internacional de Mejoramiento de Maíz y Trigo), CIAT (Centro Internacional de Agricultural Tropical), IRRI (International Rice Research Institute), IITA (International Institute of Tropical Agriculture), ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), the Asian Vegetable Research and Development Center and the International Potato Center.

The Soybean Resource Base is being built around existing major domestic programs in soybeans at the University of Illinois and its cooperating agencies, and would specifically develop from the cooperative INTSOY of the University of Illinois and the University of Puerto Rico.

The need for such an International Soybean Resource Base arises from the major protein-calorie deficiencies which exist among a significant proportion of the world population, and from the unique potential of soybeans (Glycine max), with 40 percent protein and 20 percent oil, to aid in satisfying food needs. The International Soybean Program INTSOY, and the International Soybean Resource Base into which it is being developed, is concerned with all aspects of soybeans from planting the seed to consumption--production, harvesting, marketing, processing and use. The major emphasis is on exploiting the unique potentials of soybeans as a source of protein for direct human consumption. The analytical thrust centers on the problems of tropical and subtropical environments as potential areas for production and use of soybean protein foods in human diets.

Work done by the University of Illinois over a period of several years, partially supported by the Agency for International Development and the Rockefeller Foundation, has developed considerable competence and confidence in the potentials to be realized from expanded production and utilization of soybeans to alleviate the protein-calorie deficiency problem. On the production side, work under the auspices of INTSOY has been concentrated in agronomy and entomology. Food utilization work has built on the discovery and perfection of the "Illinois Process" for using cooked whole soybeans. This has included development of a simple, inexpensive method to treat whole soybeans and deactivate the enzyme that catalyzes an objectionable beany flavor. It is now recognized that the resulting bland whole soybean can be used as the chief ingredient in a wide variety of food products.

Work in Puerto Rico, which will be described in detail by Dr. Abrams, has concentrated on food legumes, winter seed increases and more recently on conducting INTSOY varietal and cultural experiments. The unique resources--human and enviromental--that Puerto Rico adds to the program, greatly strenghten INTSOY's capacity to respond to needs of other countries in tropic and subtropic regions.

While considerable progress has been made in certain aspects of

the soybean program, resources are not yet available to attain the objective of establishing the International Soybean Resource Base in line with the concept of giving balanced attention to all phases of the work from the soybean seed to consumption. Neither is adequate funding available to permit the full potential of the Base as visualized, to be made available in an "outreach" program through national and international organizations.

As many of you are aware, a proposal has been prepared for the establishment of an International Soybean Resource Base and is presently being considered by the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research.

INTSOY is making progress. A network of cooperative varietal trials have been established in many countries. Dr. Keith Whigham will present the details and some results of these trials as well as plans for the immediate future. Other INTSOY staff will be discussing the details of their programs.

As INTSOY develops--we are sometimes asked--Is INTSOY setting up its own germ plasm bank? The answer is No. For many years the World Germ Plasm Soybean Collection has been most adequately maintained, evaluated and disbursed by the USDA Regional Soybean Laboratory; by Dr. R. L. Bernard at Urbana, Illinois and by Dr. E. E. Hartwig at Stoneville, Mississippi. INTSOY has strong cooperative linkages with the Regional Soybean Laboratory and will continue to rely on and assist the Laboratory relative to germ plasm. Hopefully, the tropical and subtropical soybean germ plasm will be maintained by an extension of the proven system of the Regional Laboratory.

Recently, Dr. Ted Hymowitz, of the Dept. of Agronomy, Univ. of Illinois, and a pioneer in international soybean research, has developed a computerized germ plasm information system in which all information from the more than 3600 lines and varieties is recorded. This information will be made available to soybean research personnel throughout the world. The system is set up to accommodate 140 different characteristics of each strain.

The International Soybean Program has had, since April 1973, a Basic Ordering Agreement with USAID, i.e., an outreach program. This BOA provides a mechanism whereby countries can make requests for technical services and, if INTSOY can respond to the request, a Task Order is issued which covers the details of the contract. Task Order No. 1 of the Basic Ordering Agreement provides assistance to the Government of Guyana to diversify its agriculture with particular reference to soybean research, production, marketing and processing. The level of effort of this task order is 7 technicians for a total of 10.5

man-months. It is anticipated that other requests for technical services will be developed into task orders in the near future.

The linkage and outreach functions of INTSOY will be vital to the development of a truly international program. The appropriate structure for executing many of the functions is not clear. Probably a variety of arrangements will be necessary, depending on local conditions and the requirements of the special funding agencies.

We are anxious to develop linkages in the very near future with the international centers; especially IITA in Nigeria, the Asian Vegetable Research and Development Center in Taiwan, CIAT in Colombia and ICRISAT in India.

The listing of University of Illinois International Soybean Program Staff Personnel is indicated in Table 5 along with the projected expansion for the immediate future. Of course not all these staff members are funded by INTSOY but they are, in addition to other personnel not listed, an integral part of the program.

In summary, re-emphasis is given to the fact that INTSOY is a research and education program of the University of Illinois and the University of Puerto Rico. While it was formally established in 1973, its organizational roots are planted in the long-standing international interests and activities of the University of Puerto Rico in food legumes and more recently in soybeans; in the domestic soybean work of the University of Illinois and other cooperation agencies, particulary the U.S. Department of Agriculture; and in the tropical and subtropical expertise and advantages of the University of Puerto Rico.

Thus, there exists a strong base of excellence on which to build an international program. The building of that program is well underway. We hope it will soon develop into a full-fledged International Soybean Resource Base of benefit to all.

In conclusion, I would like to say that the University of Illinois is proud and pleased to be associated with the University of Puerto Rico and to visit your beautiful island, especially during this time of the year.

TABLE 5

UNIVERSITY OF ILLINOIS
INTERNATIONAL SOYBEAN PROGRAM STAFF PERSONNEL

Orville G. Bentley, Dean, College of Agriculture.
George K. Brinegar, Director, Office of International Programs and Studies.
Wilbur D. Buddemeier, Director, International Agricultural Programs.
William N. Thompson, Director of INTSOY and Associate Director of International Agricultural Programs.
Raúl Abrams, Soybean Coordinator - University of Puerto Rico, College of Agriculture, Mayaguez Campus.
T.A. McCowen, Director, Office of Overseas Projects; Assistant Director of INTSOY

I. PROFESSIONAL STAFF:

Department of Agronomy	Carl N. Hittle
	D. Keith Whigham
Department of Food Science	Alvin I. Nelson
	Leslie K. Ferrier
Agricultural Entomology	George L. Godfrey
Department of Plant Pathology	James B. Sinclair
Department of Agricultural Economics	Sheldon W. Williams
Department of Agricultural Engineering	Errol D. Rodda
Department of Home Economics	Frances O. Van Duyne

II. FUTURE EXPANSION:

A. A soybean breeder is being recruited and will be stationed at Mayaguez.
B. A plant pathologist (virologist) is being recruited.
C. An entomologist is being recruited.
D. In the near future increased emphasis will be given to Agr. Economics, Communications, Home Economics and Agricultural Engineering.

III. RESEARCH ASSISTANTS:

There are several research assistants in the various departments.

IV. TECHNICIANS:

Assigned to the various departments.
Additional technicians are presently being recruited.

UNIVERSITY OF PUERTO RICO 211(D) SOYBEAN PROGRAM

Raúl Abrams 1/

La Universidad de Puerto Rico recibió un donativo por la cantidad de $500,000 de la Agencia Internacional para el Desarrollo del Departamento de Estado de los Estados Unidos de Norte América con el propósito de fortalecer y mejorar los conocimientos para la producción de habas soyas en el trópico y subtrópico. Este donativo mejorará la capacidad profesional y las facilidades del Colegio de Ciencias Agrícolas en el área de fitopatología, control de insectos y prácticas agronómicas en habas soyas y otras leguminosas. Es un programa cooperativo con la Universidad de Illinois y facilitará el intercambio de profesores, estudiantes y el entrenamiento de personal para el manejo y producción de habas soyas en el trópico. El programa estará coordinado con otros programas del Colegio de Ciencias Agrícolas en el área de suelos tropicales y de producción de cosechas.

In October 1973, U.S.A.I.D. funded 211(d) grants for the Universities of Puerto Rico and Illinois. The major objectives of the University of Puerto Rico program are to increase and improve the capabilities of the university in order to provide needed training, research and informational linkages, technical assistance and consultation on major problems related to limiting diseases and associated insects and cultural practices of soybeans and other food legumes for the tropical and subtropical areas.

The University of Puerto Rico has long experience with production of food legume crops like field beans and pigeonpeas, as well as other crops on tropical soils which will be of great value for the production of soybeans for the tropics.

Special emphasis would include the strengthening of Puerto Rico's present capacities to do research on the control of limiting tropical diseases and associated insects, the identification of sources of resistance and in collaboration with the University of Illinois, the incorporation of such improved characters into special plant populations or

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1/ Chairman and Professor, Agronomy Department, College of Agricultural Sciences, University of Puerto Rico, Mayaguez Campus.

lines. Further, emphasis would also be placed on the development of improved management practices that may be needed under tropical and subtropical conditions.

The major item to receive research attention will be screening of cultivars for resistance to limiting diseases and associated insects, weed control, pre and post emergence herbicide treatments suitable for the tropics, protein, aluminum toxicity and efficiency in utilization of minor elements such as Zn, Cu and Mn. Other items to receive attention as appropriate are: (a) plant population and date of planting studies which will help design a soybean ideotype for the tropics, (b) soil and water management practices, (c) draught and excessive moisture tolerance, (d) fertilizer studies, (e) nitrogen metabolism with emphasis on rhizobium nodulation.

For the implementation of this program, the College of Agricultural Sciences has a well-developed, experienced staff with more than 100 scientists with Ph.D degrees. A large number of courses are offered in areas related to this 211(d) program and supporting courses offered by other faculties in the University are an integral part of the work in agriculture. In addition to research on Campus, branch experiment stations located in Isabela, Lajas, Corozal, Río Piedras, Gurabo, Adjuntas and Ponce provide a wide area of different ecological sites, with more than 2,500 acres available for field work, with adequate laboratories and technical and support personnel well equiped to handle almost any kind of research with soybeans.

The College of Agricultural Sciences is also involved in a Consortium of Universities with Cornell, North Carolina, Hawaii and Prairie View, Texas, under the auspices of AID, for enhancing the competence of these institutions for teaching, research, service and consultation on soils of the tropics and their use for food and fiber production. The research program from this grant will provide basic soil information required by the project on soybeans. This is a vitally important research area, since many areas of the tropics will remain incapable of achieving their food production potential until adequate soil management practices are developed.

The University of Puerto Rico will also provide for this program competence in the area of disease studies and related insect problems of food legumes through a cooperative project with the USDA Federal Experiment Station. It is our goal to coordinate this program with the on going 211(d) projects.

The College of Agricultural Sciences also maintains close contact and cooperation with the U. S. D. A. Federal Experiment Station at Mayaguez. Facilities like adequate laboratories, technical and support

personnel and farms in Mayaguez and Isabela make the Federal Experiment Station an outstanding support for this soybean program.

The Puerto Rico Nuclear Center, a research and training institution sponsored by the Atomic Energy Commission, is operated by the University of Puerto Rico. The Nuclear Center offers students the opportunity for advanced training in the application of nuclear techniques to problems in tropical agriculture. It is expected to be of possible assistance in the modification of specific inheritance factors by irradiation for improved resistance and yield characters.

Recently, the College of Agricultural Sciences submitted to AID, and is already approved but not funded, a research project proposal in the area of Crop Production and Land Potential of Benchmark Soils of Latin America. The main goals of this project are (1) to correlate food crop yields with soil properties and management practices on a network of benchmark soils of the tropics, (2) to test and establish criteria for the transfer of agrotechnology among tropical countries, and (3) to demonstrate the agricultural potential of tropical red upland soils in LDCs of Latin America.

We envision a close collaboration between the 211(d) tropical soybean program and the soils benchmark project for the transfer of agricultural knowledge within the tropics.

The following operational plan will be followed to strengthen and improve our program:

1. A senior staff in the area of Plant Pathology has already been appointed to work half time with the project teaching graduate courses and serving as chairman of graduate students in thesis research projects.

2. On July 1st another Plant Pathologist will be appointed full time to teach undergraduate and graduate work and do research in this area.

3. We are looking for a senior staff member in the area of weed control. The appointee will teach undergraduate and graduate courses in weed control in the tropics and do research work along this area. We are hopeful that we can fill this position before next July.

4. One field and one laboratory technician were appointed last November to provide support to the staff members.

5. Three graduate assistantships have been granted for students

to work towards the Masters degree in the area of plant pathology, nematology and breeding of soybeans.

Training and research in the tropics and training through exchange of students are part of the collaborative relationships between Puerto Rico and Illinois that this grant will make possible, in order to develop a much stronger coordinated program in soybean research and production under tropical conditions.

Another function of this grant will be the training of personnel in subject matters which will capacitate them to serve the University of Puerto Rico international legumes improvement and development programs. The universities of Illinois and Puerto Rico already have a group of top-ranking scientists with soybean and related legume expertise. In order to increase each university's ability to extend its responsibility in the international field, these men will be called on. They will cooperatively develop and conduct courses on a wide range of topics important in soybean research and, by providing this training, develop new personnel to work in soybean production in the tropics.

Linkages are planned with major international centers in the tropics as well as leading soybean producing countries.

INTERNATIONAL VARIETY TRIALS

D.K. Whigham

Las pruebas para la evaluación de variedades de INTSOY fueron establecidas a principios del 1973 para determinar la adaptabilidad de las soyas en las áreas tropicales y subtropicales del mundo. En esas pruebas se evalua la producción de variedades comerciales introduxidas contra variedades locales. El plan original incluía 20 variedades, analisaba para contenido de proteína y aceite asi como susceptobilidad a insectos y enfermedades. Las variedades fueron evaluadas bajo una gama de variaciones ecológicas. Hasta la fecha sólo 10 localidades han sometido los datos experimentales para análisis por lo que no es posible llegar a conclusiones. Sin embargo, se incluyen los datos disponibles que indican variaciones marcadas en cuanto al comportamiento de los cultivares en diferentes áreas. Se discuten estas variaciones en relación a las respectivas localidades. Se discuten, además, los planes para el futuro, que incluye la ampliación de las variables a estudiarse.

The INTSOY variety evaluation trials were established in early 1973 to determine the adaptability of soybeans throughout the tropical and subtropical areas of the world. Commercially available soybean varieties were used because of the quantity of seed required. Large quantities of experimental lines were not available. All varieties were selected, on grain yield performance, from each maturity group classification used in the United States.

Many cooperating countries had tested soybean varieties in the past, but the more recent varieties had not been tested in those areas until the INTSOY trial was introduced. The trial was designed to allow the cooperator to substitute local varieties into the test and comparisons were made on an equal basis. A comparison of the introduced and local soybean varieties allowed the cooperator to determine if the local material was the best available. Results from the trials indicated those local varieties which have potential for introduction into other areas with similar environmental conditions.

When soybeans are a new crop introduced into a country, the INTSOY trial provides a wide range of characteristics for evaluation.

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The differences in vegetative growth habit and length of maturity are the most striking. These characteristics also vary from environment to environment.

The 1973 INTSOY trial consisted of 20 varieties which were replicated four times in a randomized complete block design. The plots were 6 meters long and four 60 cm rows wide. The harvest plot was 5 meters of the two center rows. Eleven plant and seed variables were measured. Protein and oil content are determined from seed of varieties from each location. A survey of the insect and disease pests was also requested.

Figure I shows the areas of the world where INTSOY trials are tested. Most of the cooperating countries are within 20 degrees of the equator; however, there are cooperators as far as 35 degrees north of the equator. Table I lists the names of each cooperating country and the number of variety evaluation trials sent to them during 1973. A total of 90 trials have been distributed during the year. Of the 33 cooperating countries, one-third are in the Asia region and they received a total of 42 trials. A list of the cooperators in each country is found as an appendix to this paper.

The trial is tested at altitudes from sea level to 2000 meters. Daylength may vary more than two hours during a season at some locations. Cool night temperatures prolong the growth cycle of the soybean plants tested at high altitudes. Rainfall varies considerably from site to site. Locations like Egypt and Sudan rely completely on irrigation for moisture. Rainfall intensity, wind velocity, soil type and soil fertility are only a few environmental variables under which these varieties are tested.

At the present time ten locations have returned the data for analysis. The analysis of variance for grain yield was determined for each location. All variables will be analyzed when more data are available. Table II presents the yield results for each of the ten locations mentioned above. Unfortunately, stand establishment was not uniform at many locations. The varieties Jupiter, Bonus and Hutton suffered from poor stand most frequently.

At Angunukulapalessa, Sri Lanka, Harosoy 63 produced the highest yield but the 3 ton yield was not significantly different from Improved Pelican. Both early and late maturing varieties have produced high yields at this location. At another location, Maha Illuppallama, Jupiter did not have the stand establishment problem and produced the highest grain yield. All other varieties yielded significantly less than Jupiter, which was the longest maturing variety (109 days), and the tallest variety (73 cm) at that location. The trial was planted in May at

Table: I 1973 INTSOY VARIETY EVALUATION TRIALS

Region	Country	Number of Trials	Region	Country	Number o Trials
Africa			Mesoamerica		
	Egypt*	1		Belize	3
	Ethiopia*	3		Costa Rica	4
	Ghana	3		Guatemala	2
	Kenya	1		Mexico	3
	Sierra Leone	2		Nicaragua	1
	Somalia*	2		Puerto Rico	6
	South Yemen*	1			
	Sudan*	1	Middle East		
	Tanzania	3		Iran*	1
				Iraq*	1
				Jordan*	2
				Syria*	1
Asia					
	Afghanistan*	1			
	India	2	South America		
	Indonesia	5		Colombia	3
	Malaysia	2		Ecuador	2
	Pakistan*	3		Peru	2
	Philippines	3			
	South Viet Nam	3			
	Sri Lanka	12			
	Taiwan	2	TOTAL - Countries		33
	Thailand	7	TOTAL - Trials		90
	Tonga	2			

*FAO Cooperating

Table: II

INTSOY VARIETY EVALUATION TRIAL YIELD RESULTS

Location - Angunukulapalessa, Sri Lanka

Latitude - $6^{o}20'$ N   Altitude - 10 meters

Date planted - June 28, 1973
Date harvested - Sept. 13, 1973 to Sept. 29, 1973

Variety	Grain Yield (Kg/ha)
Harosoy 63	3049
Adelphia	2900
Davis	2846
Coker Hampton 266A	2774
Semmes	2684
Clark 63	2672
Williams	2657
Dare	2567
Hark	2380
Bonus	2322
Improved Pelican	2299
Pickett 71	2135
Cutler 71	2134
Lee 68	2127
Calland	1995
Bragg	1989
Hardee	1610
Hutton	1190
Hill	1077

Coefficient of variation - 23.65

LSD (5%) 760

Location - Maha Illuppallama, Sri Lanka

Latitude - $8^{o}5'$ N   Altitude - 138 meters

Date planted - June 21 + 22, 1973
Date harvested - Sept. 10, 1973 to Oct. 9, 1973

Variety	Grain Yield (Kg/ha)
Jupiter	2832
Pickett 71	2392
Bragg	2349
Coker Hampton 266A	2297
Williams	2284
Adelphia	2280
Davis	2262
Dare	2252
Hutton	2229
Lee 68	2217
Bonus	2202
Clark 63	2194
Tainung R-1	2105
Semmes	2092
Improved Pelican	2035
Pb-1	1962
SJ-2	1907
Hill	1884
TK-5	1875
Harosoy 63	1850

Coefficient of variation - 9.80

LSD (5%) - 300

Table: II (continued)

Location - Alutharama, Sri Lanka

Latitude - 7°30' N Altitude - 266 meters

Date planted - May 20, 1973
Date harvested - Aug. 4, 1973 to Sept. 14, 1973

Variety	Grain Yield (Kg/ha)
Hardee	3537
Bragg	3434
Hutton	3417
Lee 68	3391
Semmes	3192
Calland	3151
Davis	3097
Clark 63	3011
Cutler 71	3007
Coker Hampton 266A	2912
Harosoy 63	2832
Bonus	2772
Pickett 71	2594
Improved	2445
Hill	2375
Dare	2354
Williams	2255
Adelphia	2010
Hark	1747
Jupiter	1099

Coefficient of variation - 20.29

LSD (5%) - 780

Location - Gannoruwa, Sri Lanka

Latitude - 7°15'N Altitude - 457 meters

Date planted - June 6, 1973
Date harvested - Aug. 30, 1973 to Sept. 27, 1973

Variety	Grain Yield (Kg/ha)
Hardee	3986
Calland	3781
Davis	3654
Pickett 71	3554
Coker Hampton 266A	3536
Improved Pelican	3489
Jupiter	3457
Williams	3454
Semmes	3302
Clark 63	3274
Adelphia	3236
Dare	3184
Cutler 71	3167
Lee 68	3157
Harosoy 63	3046
Bragg	2986
Hill	2944
Hutton	2927
Bonus	2881
Hark	2504

Coefficient of variation - 11.82

LSD (5%) - 545

Table: II (continued)

Location - La Granja, Philippines

Latude - $10^{o}24'$ N Altitude - 74 meters

Date planted - May 18, 1973
Date harvested - Aug. 1, 1973 to Sept. 27, 1973

Variety	Grain Yield (Kg/ha)
Williams	2954
Bonus	2687
Bragg	2552
Hardee	2534
Pickett 71	2409
Davis	2320
Clark 63	2299
Coker Hampton 266A	2289
Harosoy 63	2287
Hill	2190
Semmes	2162
Hutton	2157
Adelphia	2140
Lee 68	2069
Hark	2049
Dare	2039
TK-5	1574
Improved Pelican	1240
L - 114	620

Coefficient of variation - 13.21

LSD (5%) - 397

Location - Los Banos, Phillipines

Latitude - $14^{o}10'$ N Altitude - 15 meters

Date planted - June 1, 1973
Date harvested - Aug. 24, 1973 to Sept. 17, 1973

Variety	Grain Yield (Kg/ha)
Clark 63	3512
Cutler 71	3441
Davis	3405
Adelphia	3364
Pickett 71	3306
Dare	3306
Williams	3188
CES 434	3132
Semmes	3092
Hutton	3071
Lee 68	3059
Hill	2966
Bragg	2827
Coker Hampton 266A	2717
Harosoy 63	2632
Hark	2200

Coefficient of variation - 7.40

LSD (5%) - 302

Table: II (continued)

Location - Mayaguez, Puerto Rico

Latitude - 18^{o} N Altitude - 30 meters

Date planted - June 29, 1973
Date harvested - Sept. 21, 1973 to Nov. 6, 1973

Variety	Grain Yield (Kg/ha)
Hardee	2304
Jupiter	1867
Davis	1752
Hill	1715
Improved Pelican	1687
Coker Hampton 266A	1385
Hutton	1259
Semmes	1250
Clark 63	1167
Dare	1165
Lee 68	1162
Pickett 71	1159
Cutler 71	1117
Bragg	1102
Bonus	954
Williams	889
Hark	632
Adelphia	565
Harosoy 63	482
Calland	243

Coefficient of variation - 24.74

LSD (5%) - 415

Location - Isabela, Puerto Rico

Latitude - $18^{o}28'$ N Altitude - 128 meters

Date planted - July 9, 1973
Date harvested - Sept. 24, 1973 to Oct. 29, 1973

Variety	Grain Yield (Kg/ha)
Coker Hampton 266A	3036
Hardee	2967
Williams	2882
Jupiter	2861
Semmes	2826
Clark 63	2791
Pickett 71	2774
Davis	2742
Hutton	2632
Dare	2502
Hark	2379
Harosoy 63	2374
Cutler 71	2370
Adelphia	2367
Lee 68	2357
Bragg	2354
Hill	2307
Bonus	2264
Calland	2034
Improved Pelican	1989

Coefficient of variation - 11.29

LSD (5%) - 404

Table: II (continued)

Location - Swat, Pakistan

Latitude - 34° N   Altitude - 1200 meters

Date planted - May 16, 1973
Date harvested - Sept. 30, 1973 to Nov. 29, 1973

Variety	Grain Yield (Kg/ha)
Lee 68	4824
Davis	4541
Pickett 71	3784
Dare	3784
Bragg	3594
Semmes	3406
Cutler 71	3406
Hill	3216
Improved Pelican	3216
Williams	3031
Hutton	2837
Hardee	2744
Clark 63	2270
Calland	2270
Coker Hampton 266A	1715
Harosoy 63	1702
Hark	947
Adelphia	662
Bonus	567

Coefficient of variation - 12.83

LSD (5%) - 499

Location - Citayam, Indonesia

Latitude - 6° S   Altitude - 75 meters

Date planted July 17, 1973
Date harvested - Oct. 5, 1973 to Oct. 24, 1973

Variety	Grain Yield (Kg/ha)
Clark 63	2175
Harosoy 63	2157
Williams	2010
Bonus	1975
Adelphia	1902
Hill	1895
Hardee	1879
Semmes	1874
Dare	1845
Lee 68	1742
Pickett 71	1712
Davis	1684
Bragg	1644
Hutton	1572
Coker Hampton 266A	1499
Ringgit	1497
Improved Pelican	1369
Sumbing	1220
No. 29	1090
Jupiter	723

Coefficient of variation - 11.63

LSD (5%) - 274

FIGURE I

COUNTRIES COOPERATING WITH INTSOY

Alutharama, Sri Lanka and there was no significant difference in yield between the top 12 varieties. At Gannoruwa eight varieties were not significantly different than Hardee, the highest yielding. The highest grain yield from Sri Lanka trials was produced at the location with the greatest altitude.

In the Philippines the introduced varieties did very well compared to local entries at La Granja. Williams showed a yield potential of nearly twice as much as TK-5 and almost five times greater than L-114 which are the local entries. At the Los Banos location, the yields were higher but the top six varieties were no different statistically.

In Puerto Rico the yields were not very high at Mayaguez, but Hardee was better than the other 19 varieties. Hardee required 110 days to mature and Jupiter matured in 131 days. Calland yielded only one-tenth as much as Hardee. The yields at Isabela were higher and more uniform.

The highest yield recorded was at 1200 meters in Swat, Pakistan. This location was also the most northern to report yields. Lee 68 and Davis produced the highest yields, which were eight times greater than Bonus. Lee 68 required 149 days to mature, whereas Hardee required 170 days and Calland only 110 days.

The top yield recorded at Citayam, Indonesia was the poorest top yield of all ten locations. Citayam was also the only location to report from the southern hemisphere. The range in maturity for all varieties was only 19 days. The high yielding varieties were early maturing. The local entries did not compete favorably with the introduced varieties. Local varieties were not selected for their response to fertilizer and therefore were very vegetative and tended to lodge.

Of the ten locations reported, all trials were planted between May 26 and July 17, 1973. The range in latitude of the trial sites was from 6°S to 34°N. The varieties were tested at altitudes from 10 meters to 1200 meters. The highest grain yield varied from 2175 to 4824 Kg per hectare. The variety Davis produced yields which were not statistically different from the highest yield at 6 of the 10 locations. Clark 63, Williams, and Coker Hampton 266A produced high yields at 5 locations. These results are only the beginning and when all the results are available more analyses will be made. By the end of this year more reliable conclusions can be made from the results.

A composite seed sample from the four replications was analyzed for protein and oil content. The results from eleven locations are presented in Table III. No statistical analysis was made.

At most locations the protein and oil content was greater than when the same varieties were grown in the United States. The highest protein content was found in Bonus seed produced in Pakistan. Hark yielded the least protein when tested in Ghana. Pickett 71 grown in the Philippines and Adelphia from Ghana yielded the highest oil content. A local entry in Indonesia, No. 29, yielded the least amount of oil. Poor nodulation and low nitrogen fertilization of the plants reduced protein content. High temperatures increased oil content.

The 1974 INTSOY Variety Evaluation Experiments are now being prepared for distribution. Many changes have been made from the 1973 trials. In response to criticism from many cooperators, the size on the trial has been reduced. A total of 15 varieties, rather than 20, will be tested and row length will be reduced to 5 meters. Three varieties are new entries in the test and the remanining 12 are being tested for a second consecutive year. The cooperator may substitute two local varieties into the test for comparison.

Many of the variables to be recorded will be the same as in 1973. However, a few new variables will be added. To determine the components of yield the cooperators will be asked to record the following: days to flower, days to maturity, nodule number and dry weight, plant height; pods per plant, plant number, and seed weight. Information will also be requested on lodging, shattering, seed quality and disease pests for each plot. A new type of data sheet is being prepared which should be more convenient to use.

Treatment of the seed with a fungicide will be completed prior to distribution. The cooperator will be asked to apply Rhizobium japonicum to the seed just prior to planting. The seed will be packaged in individual row envelopes and labelled according to the field plan. The experiment will include instructions for management and data collection. Pertinent information about the experimental site and environmental conditions during the test period will be requested. Identification of the major soybean pests will also be solicited. Protein and oil content will be determined for all varieties grown at each location. Seed analysis indicates seed compositon changes due to management and environment. When sufficient data is collected from each location to indicate the varietal characteristics most desirable, zonal evaluation tests will replace the standard test. Cooperating sites will be categorized into zones according to environment. Only those varieties or lines which have potential in the zone will be tested on the sites of that zone. New material will be tested in more than one zone until adaptability is identified.

Table: III

PROTEIN AND OIL ANALYSIS RESULTS OF THE 1973 INTSOY VARIETY TRIALS

LOCATION	SRI LANKA								PHILIPPINES	
	ANGUNUKULAPALESSA		MAHA ILLUPPALLAMA		ALUTHARAMA		GANNORUMA		LOS BANOS	
	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %
Variety										
Jupiter					43.8	21.3	44.8	23.3	44.4	24.1
Coker Hampton 266A	41.3	25.2	43.6	24.4	39.9	25.0	41.8	24.1	39.5	26.2
Hutton	46.0	22.6	45.3	23.3	44.0	23.1	43.1	23.2	42.5	24.5
Improved Pelican	43.8	22.6			43.4	23.6	45.6	22.9		
Bragg	43.0	22.5	43.7	24.4	43.7	23.2	39.4	24.1	39.8	26.2
Semmes	44.2	23.6			43.7	25.3	43.1	24.4	39.3	26.2
Davis	43.0	23.0	44.1	23.5	40.9	23.9	42.2	22.3	41.1	25.0
Lee 68	44.4	23.0	44.7	23.3	43.7	23.5	43.0	23.4	42.1	25.0
Pickett 71	42.7	24.0	43.8	23.9	43.0	24.1	42.8	23.2	39.0	27.0
Dare	41.2	24.5	40.5	24.8	38.6	25.0	41.9	24.1	37.9	26.8
Hill	39.3	24.2	43.3	23.0	37.4	24.3	40.0	23.4	40.0	24.8
Bonus	42.0	24.5	43.1	24.5	41.5	26.0	43.1	24.4	42.4	25.2
Clark 63	41.3	24.4	42.7	24.6	40.1	25.8	41.4	24.1	41.6	25.3
Adelphia	40.6	24.4	42.4	23.5	39.2	25.6	41.7	24.3	40.5	24.8
Williams	43.4	24.0	43.8	23.7	42.0	25.2	42.5	23.8	42.0	25.6
Harosoy 63	41.3	23.5	43.1	23.6	39.7	25.2	41.6	24.4	41.6	24.6
Hark	40.0	24.6			39.6	25.2	41.3	24.5	41.3	25.6
Hardee	44.7	23.0			45.0	23.2	45.4	23.0	43.6	25.0
Calland	42.3	23.5			42.1	23.8	42.8	22.0		
Cutler 71	41.7	25.0			39.1	24.9	41.5	23.7	41.5	25.2
TK-5			45.1	22.3						
Tainung R-1			44.9	21.9						
SJ-2			46.1	21.0						
Pb-1			43.4	24.2						
CES-434									46.0	22.2
L-114									46.8	20.0

Table: III (continued)

LOCATION	PUERTO RICO						PAKISTAN		INDONESIA		GHANA	
	MAYAGUEZ		ISABELA		LAJAS		SWAT		CITAYAM		LEGON	
	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %	Protein %	Oil %
Variety												
Jupiter	41.4	24.8	37.7	24.5	44.7	22.4			43.0	22.5	40.5	26.2
Coker Hampton 266A	41.0	26.0	36.5	25.3	41.8	25.4	39.3	22.0	41.0	26.0	40.4	26.3
Hutton	44.0	25.0	37.5	24.2	43.4	24.2	42.4	20.6	45.3	23.5	42.0	24.0
Improved Pelican	41.3	24.4	39.3	20.9	44.4	23.2	42.2	21.0	43.3	23.5	39.8	25.1
Bragg	42.0	25.5	36.5	25.3	42.4	24.4	41.6	22.3	43.3	24.0	40.0	26.2
Semmes	41.1	26.0	39.1	24.7	44.1	24.1	41.4	22.4	42.3	25.5	39.9	26.0
Davis	42.7	24.4	37.7	24.2	42.3	23.7	40.2	22.6	44.0	24.2	40.5	24.0
Lee 68	44.1	23.7	40.5	24.6	46.4	23.2	42.8	21.8	44.0	24.0	41.3	24.6
Pickett 71	42.9	25.0	39.2	24.7	44.1	23.2	41.5	23.2	42.0	25.0	41.4	24.5
Dare	40.4	25.8	38.4	25.1	38.7	25.0	41.3	23.8	40.5	26.3	40.4	25.3
Hill	41.7	23.1	39.2	23.1	40.8	24.0	40.5	22.4	42.0	23.8	38.7	24.9
Bonus	44.9	22.8	41.1	22.6	44.3	23.6	47.6	20.5	43.2	25.3	38.6	26.6
Clark 63	43.0	24.5	39.7	24.1	43.4	22.9	45.6	22.9	43.6	23.9	39.3	26.0
Adelphia	42.7	22.8	38.4	24.4	41.6	22.9	43.4	23.0	42.0	24.6	36.7	27.0
Williams	44.4	24.4	39.3	24.8	42.5	24.4	45.9	22.4	42.7	24.6	41.0	25.2
Harosoy 63	45.4	22.4	40.2	22.5	41.6	24.0	46.5	21.1	40.5	25.1	38.4	25.6
Hark	44.1	24.5	41.2	22.6	40.5	25.2	46.4	20.9			36.0	26.0
Hardee	42.6	24.3	38.8	24.2	44.8	23.0	42.3	20.4	43.8	24.2	37.6	26.8
Calland	45.2	21.4	38.8	22.6	42.5	23.2	46.7	20.8			41.1	24.5
Cutler 71	42.7	24.0	39.3	23.9			44.6	22.0			39.6	25.3
Kanrich					41.1	23.9						
Ringgit									43.1	20.1		
Sumbing									44.5	19.5		
No. 29									47.0	18.0		

APPENDIX

Cooperators with INTSOY in 1973

Region	Country	Cooperator	
Africa			
	Egypt	Dr. Abdul Hafiz Regional Consultant Cereal Imp. & Prod. Proj. Food & Agri. of United Nations 110 Sharia Kasr el Aini P.O. Box 2228 Cairo, United Arab Republic	Dr. M. Hakam Director Grain Legume Station Field Crops Res. Inst. Giza, Orman - Cairo Egypt
	Ethiopia	Dr. Dagnatchew Yirgou General Manager Institute of Agricultural Res. P.O. Box 2003, Addis Ababa Ethiopia	Mr. Zewudu Oumer Agronomist Awassa Experiment Sta. P.O. Box 6 Awassa, Ethiopia
	Ghana	Dr. Bob Dadson Department of Crop Science Faculty of Agriculture University of Ghana Legon, Ghana	
	Kenya	Dr. A. M. Gurmah Dept. of Crop Production Kabete Campus P.O. Box 30197 Nairobi, Kenya	
	Sierra Leone	Mr. M. T. Dahniya Department of Agronomy Njala University College Private Bag Freetown, Sierra Leone	
	Somalia	Mr. M. A. Dukseyeh Head, Agricultural Res. Ser. Ministry of Agriculture Central Agri. Res. Sta. - Afgoi Mogadishu, Somalia	
	South Yemen	Dr. H. Idris Project Manager Agricultural Research Station El Kod, Aden. South Democratic Yemen	
	Sudan	Dr. M. O. M. Salih Director of Agric. Res. Corp. Wad Medani Sudan	

Tanzania	Dr. W. H. Judy USAID/Tanzania P.O. Box 9130 Dar es Salaam, Tanzania	

<u>Asia</u>

Afghanistan	Mr. Mohammad Arif Noori Director-General Research Division Ministry of Agriculture & Irri. Kabul, Afghanistan	
India	M. S. Lal Botanist (Soybean) J. N. Agricultural Univ. Jabalpur-4 (M.P.) 482004 India	Dr. M. C. Saxena Prof. of Agron. & Coord. All India Coord. Soybean Research Project G. B. Pant University Pantnagar, Dist. Nainital India
Indonesia	Dr. Russell D. Freed IRRI JL. Merdeka 99 P.O. Box No. 107 Bogor, Indonesia	Ir. Soenjoto Djojodiridjo Department of Agronomy University of Gadjah Mada Jogjakarto, Indonesa
	Dr. Fred Rumawas Director of Research Institute Pertanium Bogor (IPB) Bogor, Indonesia	
Malaysia	Dr. Ajit Singh Sidhu Mardi % Sungai Besi Post Office Serdang, Selangor Malaysia	
Pakistan	Mr. Mian Sayd, Dir. of Research Agricultural Research Institute Tarnab, Peshawar, Pakistan	Mr. S. Sayed Badshah Agri. Res. Institute Tarnab, Peshawar, Pakistan
Philippines	Dr. Fred B. Ballon Field Legume Unit of Bureau of Plant Industry Dept. of Agri. & Natural Res. Manila, The Philippines	Ricardo M. Lantican Prof., Dept. of Agronomy U.P. College of Agri. U.P. at Los Banos, College Laguna E-109, Philippines
South Viet Nam	Mr. A. Hartman (Joe) 561-48-7433 USAID/ADFA APO San Francisco, Ca. 96243	

Sri Lanka	Mr. William G. Golden, Jr. Project Leader Int. Rice Research Inst. Ceylon Ford Found. Rice Proj. Central Agri. Res. Inst. Gannoruwa, Peradeniya Sri Lanka (CEYLON)	
Taiwan	S. Shanmugasundaram Asian Veg. Res. & Dev. Ctr. P.O. Box 42 Shanhua, Tainan, 741 Taiwan, Republic of China	
Thailand	Dr. Verne C. Finkner University of Kentucky Agricultural Center Northeast Tha Phra, Khon Kaen, Thailand	Dr. Dumrong Tiyawalee Plant Science Dept. Faculty of Agriculture Chiangmai, Thailand Chiangmai, Thailand
	Dr. Sumin Smutkupt Div. of Radiation & Isotopes Faculty of Science and Arts Kasetasart University Bangkok, Thailand	Dr. Arwooth Na Lampang Soybean Proj. Leader Res. & Experiment Div. Ministry of Agriculture Bangkok, Thailand
	Bobby L. Renfro The Rockefeller Foundation G.P.O. Box 2453 Bangkok, Thailand	
Tonga	Mr. Merle M. Anders Agronomist Department of Agriculture Box 14 Nuku'alofa, Tonga	

Meso-america

Belize	Dr. J. P. Cal Agronomist Department of Agriculture Central Farm - Belmopan Caijo District - Belize British Honduras	
Costa Rica	Thomas W. Bentley Director, C.A.R.E. Apartado 3571 San Jose, Costa Rica	
Guatemala	Dr. Albert N. Plant USAID/Guatemala % U.S. Embassy Guatemala City Guatemala, C.A.	Dr. Ricardo Bressani Jefe de la Div. de Ciencias Agricolas Y de Alimentos Carretera Roosevelt Zone 11-AP Postal 1188 Guatemala, C.A.

	Mexico	Dr. Alfonso Crispin M. Instituto Nacional de Invest- igaciones Agricolas Apartados 6-882 Mexico 6, D.F.	
	Nicaragua	Mr. Mack H. McLendon Deputy Food & Agri. Officer USAID/Nicaragua % American Embassy Managua, Nicaragua	
	Puerto Rico	Dr. Marcial Rico Ballester University of Puerto Rico Agricultural Exper. Station Lajas Substation Lajas, Puerto Rico	Frank J. Julia Agronomo University of Puerto Rico Agricultural Exper. Sta. Isabela Substation Apartado 506 Isabela, Puerto Rico
		Dr. Eric G. Stone Research Geneticist USDA/ARS Southern Region Federal Exper. Station P.O. Box 70 Mayaguez, Puerto Rico 00708	
Middle East			
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	Iraq	Mr. Haji Abdul Sattar Director, Research Ind. Crops Abu Ghraib Agr. Res. Station Baghdad, Iraq	
	Jordan	Mr. S. P. Kohli FAO Agricultural Officer Groundwater Res. Project P.O. Box 565 Amman, Jordan	
	Syria	Mr. Suleman Falouh Incharge Legume & Oil Crops Agricultural Res. Institute Douma, Syria	

South America			
	Colombia	Dr. Luis H. Camacho, Head Grain Legumes Program Inst. Colombiano Agropecuario (ICA) Palmira, Colombia South America	
	Ecuador	Eng. Eduardo Calero H. Chief Research 1 Oil Program INIAP (Instituto Nacional De Investigaciones Agropecuarios) Estacion Experimental Boliche Apartado No. 7069 Guayaquil, Ecuador	
	Peru	Raul Figueroa Agriculture Exper. Station La Molina, P.O. Box 2791 Lima, Peru S.A.	Ing. Prompeyo Contreras M. Director del Centro Reg. de Investigation Agraria del Norte Ministerio de Agricultura Apartado # 116 Chiclayo, Perú

TROPICAL PRODUCTION OF SOYBEANS

Kuell Hinson 1/

La gran demanda mundial por habichuelas soyas y sus productos indican la necesidad de desarrollar nuevas áreas de producción; entre otras, las regiones del trópico. Para las regiones tropicales se puede adaptar alguna de la tecnología desarrollada para regiones templadas, pero parte de la tecnología tiene que ser modificada y en otros casos hay la necesidad de desarrollar nuevas técnicas. Las diferencias en fotoperiodo en el trópico son lo suficientemente grandes para causar cambios significativos en el desarrollo de la planta. Aparentemente la mejor condición para la habichuela soya es desarrollar la semilla cuando los días se acortan. Desviaciones de esta situación pueden causar un desarrollo y una madurez anormal de la soya. Se debe favorecer la producción de soya cuando la humedad del suelo es adecuada, pero no excesiva, y la producción es factible en cualquier suelo que provea la humedad y nutrición requerida por la planta. Se debe desarrollar variedades con carácteres necesarios para una buena producción en todos los fotoperiodos, épocas de producción, operaciones de campo y resistentes a enfermedades e insectos. Adicionalmente es necesario determinar las sepas de Rhizobium y Japonicum que se adaptan mejor a los suelos tropicales y diferentes genotipos de soya, y también el uso de hongos Mycorrhiza en suelos bajos en fósforos.

The rapid increase in world demand for soybeans and soybean products indicates a need for developing new production areas. Many tropical areas need the protein and oil that soybeans can provide. Economic situations favor local production where this is feasible. My limited experience with soybeans in the tropics suggests that soybean production can be profitable in many tropical areas.

Some production technology developed in temperate regions, particularly in the U.S., can be applied directly to tropical conditions. Other technology will need to be modified to meet special circumstances, and some of it may not apply at all.

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To expand production rapidly in the tropics, we should use all developed technology that is directly applicable, modify other technology where feasible, and concentrate efforts on problems that are peculiar to the tropics and subtropics. Developing adapted varieties is one example of an important research objective.

The segments of temperate-region technology that apply directly to the tropics and subtropics are not always obvious. This workshop should identify some of these segments. It should also point to problems for which new technology is needed. I hope that my discussion will provide some information on both aspects.

My topic "Tropical Production of Soybeans" is rather broad. I will discuss it under seven subtopics. The subject matter in some subtopics overlaps that of other main topics assigned. In preparing this discussion, I assumed that if I make the same point another speaker makes, these points are obviously important enought to be repeated; and if we have different ideas on certain points, both viewpoints need to be presented. I hope other speakers accept this philosophy.

Photoperiod Response:

The soybean probably evolved in a temperate region. Seasonal temperature changes would have forced it into a growth cycle similar to that used for soybeans in the U.S. today. We normally plant soybeans 20 to 50 days before day lengths are longest. Seed development takes place when days are shortening. In northern U.S., we use this part of the photoperiod cycle because temperature changes force us into it. In southern U.S., we use it because we get higher yields by doing so.

A similar relationship between photoperiod and plant development cycles probably is best for tropical locations. My concept of the combination of plant and environmental traits that would be near optimum for low elevation, tropical locations is as follows:

1. A determinate variety planted 20 to 50 days before maximum day length.
2. Adequate, but not excessive, soil moisture throughout the growing season.
3. 42 to 50 days to first flower.
4. About 120 days planting to maturity.
5. About 15 nodes; 30 to 36 inches stem length.
6. Good ground cover during pod filling.
7. Low rainfall and humidity, beginning at maturity

This plant development cycle is slightly shorter than that consid-

ered optimum in the U.S. It assumes adequate nutrition, good management, and an environment that is essentially stress free. Where stresses occur, or where high elevations reduce temperatures appreciably, a slightly longer cycle may be better.

Many tropical locations will not have 120 days of adequate soil moisture. At other locations planting dates must be at some other time in the photoperiod cycle, particularly where two crops are grown each year. However, a definition of a near optimum situation will help identify the nature and extent of adjustments that should be made for other situations.

At the higher-latitude tropical locations, there is considerable variation in effective day length. Figure 1 shows photoperiod cycles for 0, 10, and 20° latitudes. These data, taken from a U.S. Naval Observatory chart, assume about 24 minutes of twilight each morning and evening (sun 6° below horizon) near the equator. At higher latitudes, twilight is longer at short day periods than at long day periods, because of the angle at which the sun sets. Thus, assumed effective day length does not decrease as much below the 0° line during short days as it increases above the line during long days. Frances (CIAT Tech. Bul 2, 1972) reported a more constant deviation from the 0 base line for long and short days. However, his maximum differences for 5 or more foot candles of light are very similar to those shown in Figure 1. Thus, both sets of values indicate about the same amount of change, but slightly different photoperiods for long- and short-day calendar dates.

We recognize that the length of the dark period actually controls plant responses. However, we will follow the established pattern, which uses the reciprocal terms. Day length and photoperiod are used interchangeably.

At 0° latitude, effective day length is assumed to be constant at 12 hours and 48 minutes. At 10° the maximum variation is 70 minutes, and at 20° it is nearly 2 1/2 hours. At 20° one could have one complete growth cycle of 120 days in which day lengths would not be less than 13 1/2 hours. This gives a minumum variation of one hour and 20 minutes for the two cycles. Lower latitudes or different planting dates would, of course, result in smaller minimum differences.

Data in Table 1, taken from a paper by Johnson, Borthwick, and Leffel (Bot Gaz. 122 (2): 77-95, 1960), illustrate the effect small changes in constant day lengths can have on plant development. These data are averages for six varieties that differed in maturity date and growth type. The two indeterminate varieties differed from the four determinate varieties in some responses. However, the average data

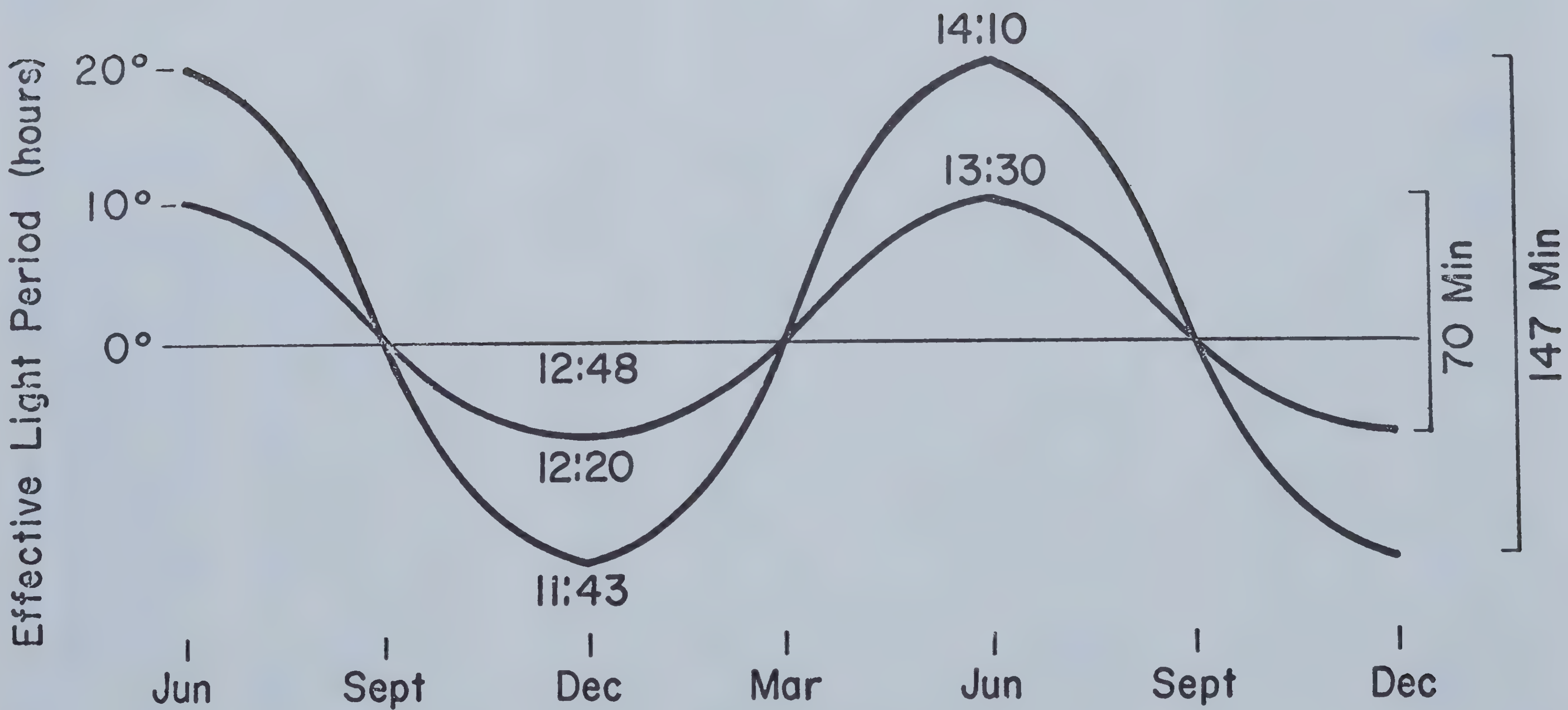

FIGURE 1. Photoperiod cycles at 0, 10, and 20° north latitude, assuming effective light when the sun is less than 6° below the horizon. From a chart based on U.S. Naval Observatory data. Points on the ordinate are for 22nd day of the respective month.

TABLE 1. Mean responses for four photoperiod treatments on six soybean varieties at all dates of planting. 1/

Constant photoperiod (hours)	Emergence to maturity (days)	Emergence to flower (days)	Flower to maturity (days)	Height (inches)
14½	135	43	91	34
14	121	37	83	30
13½	103	34	68	24
13	90	32	58	20

1/ From Johnson, H.W., H.A. Borthwick, and R.C. Leffel. Effects of photoperiod and time of planting and rates of development of the soybean in various stages of the life cycle. Bot. Gaz. 122(2):77-95. December 1960.

show about the amount of change that may be expected from relatively small differences in day lengths. The maximum photoperiod difference of 1 1/2 hours caused differences of 45 days in emergence to maturity, 21 days in emergence to flower, 33 days in flowering to maturity, and 14 inches in plant height.

The maximum photoperiod difference of 1 1/2 hours in Table 1 is only 10 minutes longer than the minimum difference for the two assumed growth cycles at 20° latitude, and it is nearly 60 minutes shorter than the maximum difference at 20°. It is 20 minutes longer than the maximum difference at 10°. And it is 10 minutes longer than the maximum difference between 0 and 20°.

These observations suggest that no single photoperiod-sensitive variety will be well adapted to all tropical photoperiods. When we consider that some potential production locations may have as few as 90 days with adequate soil moisture, and other may have 150 days, it becomes obvious that several varieties with diverse traits will be needed for good production in all environments.

A photoperiod-insensitive trait would reduce, but not eliminate, the need for multiple varieties for the tropics. Even though photoperiod-insensitive traits have been reported for soybeans, I know of no reports documenting the effectiveness of this trait in field production. My discussion assumes that tropical soybean production will depend on photoperiod-sensitive varieties.

In many tropical regions, researchers using varieties adapted to temperate regions have observed little or no difference in plant development associated with photoperiod differences equal to those in Table 1. This does not mean that such varieties are insensitive to photoperiods follow the general pattern established by data in Table 1.

Other production difficulties are likely to be associated with the direction of day length change at the higher-latitude tropical locations. To illustrate expected difficulties, we will assume that the Jupiter variety is planted at a near-optimum point in the photoperiod cycle and at another point that is not optimum. We choose Jupiter because we have data to establish some responses rather accurately. Other responses must be assumed from other data and observations. We will further assume good environmental conditions for growth and development, except for the photoperiod variable.

For Jupiter planted on June 1 at 20° north latitude, we have evidence to indicate that floral initiation will take place in about 50 days (July 20) when days are about 14 hours long; plants will flower in about 21 more days (August 10) when days are about 13 3/4 hours

long; and plants will have 18 to 22 nodes, and will mature about 150 days from planting (October 28) when days are about 12 hours long (Figure 2). Seeds are developed during decreasing day lengths which is considered optimum.

In this example, however, plants require a longer-than-optimum growing season and produce too much vegetative growth, because Jupiter is better adapted to shorter day lengths during early plant development. By planting one month later (July 1) we would expect to delay flowering about 5 days, reduce node number to 15 to 18, reduce plant height 8 to 12 inches, and delay maturity not more than 7 days if at all. This is more desirable plant development.

Now, let us assume that Jupiter is planted on March 1 at 20° north latitude. Days are about 12 hours and 25 minutes long. (Figure 2, left). We would expect floral initiation soon after true leaves are produced and flowering about 20 days later or between 30 and 40 days after planting. Days are about 13 hours and 15 minutes long, respectively, on April 1 and 10. Pod-set would then take place when days are nearly 13 1/2 hours long. This is near the day length for pod-set for the July 1 planting date in our previous example. However, the plants on which pods are set in the March 1 planting would be expected to differ greatly from those in the July 1 planting. For the March 1 planting, we would expect fewer nodes and shorter stems, because there were fewer days from planting to flower.

It is generally accepted that soybean plants set about the number of pods they can mature normally if environmental conditions influencing yield do not change greatly during pod-filling. When later environmental conditions become more favorable for high yield, plants compensate to a degree by producing larger seed. When conditions become less favorable, plants produce smaller seeds, drop more pods, or both. However, probably because of the way it evolved, the soybean acts as if day lengths after pod-set will become shorter rather than longer.

In our March 1 example, days continue to lengthen after pod-set. This results in more hours of photosynthesis per day which is a more favorable yield environment. Pod-set on relatively small plants is likely to be less than it would be on larger plants. Increased seed size is not an efficient compensating mechanism. The end results expected are: delayed and abnormal maturity, green leaves attached and green stems when pods are mature, and abnormally large seed of reduced quality.

We will not predict a maturity date for the March 1 planting, because of the complicating responses expected. If we have estimated plant size at pod-set accurately, seed size probably would be near

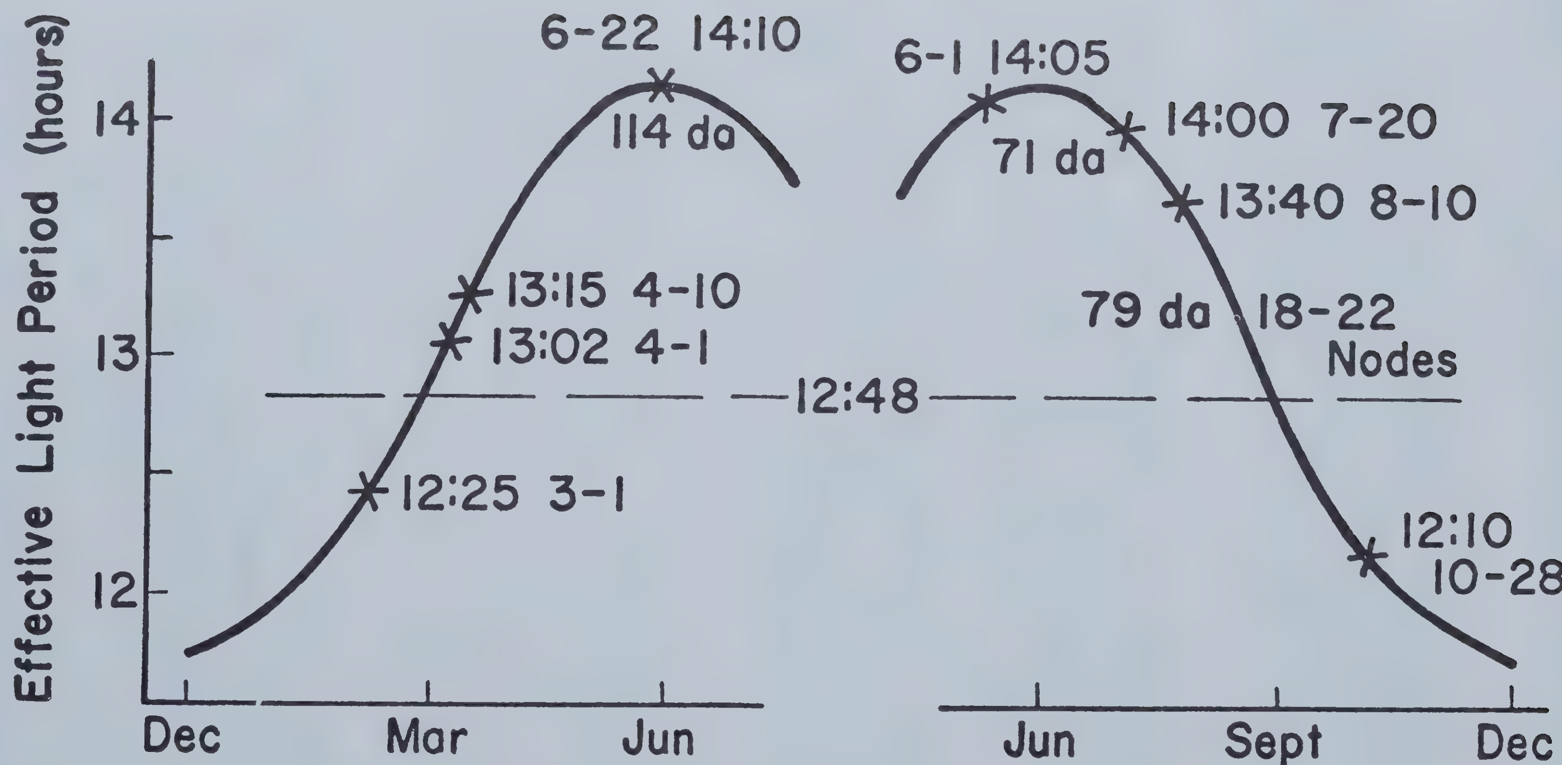

Figure 2. Assumed plant-development cycles for Jupiter soybeans planted on June 1 (right) and March 1 (left) at 20° north latitude. For the June 1 planting we assume floral initiation on 7-20, flowering on 8-10, and maturity on 10-28. For the March 1 planting we assume flowering between April 1 and 10, and maturity date is indefinite.

normal at a mid-June maturity date (about 110 days). However, maturity is likely to be much later unless dry soil, diseases, or other factors hasten maturity.

Shifting to an April 1 planting date could cause more serious problems. In Florida, I have occasionally observed that some soybeans planted about April 1 flowered when plants were small, set a few pods, became vegetative again as days continued to lengthen, flowered again when days became shorter, set more pods, and matured not far from the time they would have matured if planted on June 1. They never yielded well. Day length changes at 20° may be great enough to cause similar responses in Jupiter.

It is also possible that a further delay in planting (to May 1, for example) would prevent flowering during increasing day lengths. If this were to occur, plants would be expected to flower in early August during decreasing day lengths, be very tall and coarse, lodge excessively, and produce few seeds at close plant spacings. At wide spacings, much of the seed would be on branches that might break off before seeds mature.

I want to emphasize again that the predictions for Jupiter planted on March 1, April 1, and May 1 at 20° north latitude are based on interpolations, rather than actual data. They are not expected to be accurate in all details. For example, it would not surprise me at all if the predicted never occurred for any variety planted at short but rapidly increasing day lengths.

We should also remember that day lengths at 20° vary more and change more rapidly than they do at lower latitudes. Thus, the abnormalities predicted sould decrease with decreasing latitudes.

When it is possible to do so, planting dates should be selected that will reduce the production hazards described above. However, if large potential production areas must use the section of the photoperiod cycle considered abnormal for soybeans, a variety should be developed that would minimize hazards. The most desirable trait to incorporate is photoperiod-insensitivity. If this trait does not exist in the soybean, other desirable traits are: a relatively long period from planting to flowering, a relatively short period from flowering to maturity, possibly a shorter time from planting to maturity than is normally considered desirable, rapid early season growth, and genetically small seeds. An indeterminate growth type may also be needed to obtain adequate plant height in a short-season variety.

Rainfall Patterns and Soil Moisture:

Adequate soil moisture for good plant growth should extend from the time seeds are planted until leaves begin to yellow in normal maturity. Because soybeans are planted rather shallow, good soil moisture at planting is necessary for rapid and uniform emergence and for helping to maintain the viability of Rhizobium bacteria applied to the seed. Low rainfall and low humidity at and after maturity are needed for efficient harvesting and to prevent seed deterioration.

Many tropical areas have two wet and two dry seasons per year. The length of one or both wet seasons may be shorter than the optimum growth period for soybeans. In such climates, one should select varieties with growth period requirements that coincide with the length of time soil moisture is available, and, of course, plant at the very beginning of the wet season. Yields will be reduced if soil moisture is depleted before seeds reach physiological maturity.

Other problems are associated with wet seasons of long duration, particularly on clay soil. If one chooses a planting date that will cause plants to mature about the time rains cease, the soil may be too wet for good seedbed preparation, planting, cultivation, etc. The extent of such problems and the best solution to them will vary with locations. I will not attempt to define them further.

Earlier in this discussion we emphasized the importance of planting at the optimum time in the photoperiod cycle, and in choosing a variety that would mature in about 120 days. However, the length and type of wet season probably will utimately influence planting dates and variety choices more than the photoperiod cycle will. Irrigation is feasible in some areas to supplement rainfall and to permit use of a more desirable photoperiod.

Varieties and Population Density:

Profitable production is sometimes achieved with varieties imported from temperate regions. Varieties selected for specific adaptation to these tropical locations should produce much more. However, there are few good varieties adapted to the tropics among which to choose. Perhaps one important contribution of this workshop will be to help breeders identify the traits they should be looking for in new varieties.

Some varietal traits to consider have been discussed. My discussion has assumed that mechanized farming will be used. However, in some areas a significant amount of production may come from small family units, which use primarily hand labor. Where production is

primarily by hand labor, a taller growing variety, planted at a lower population density, may be more desirable.

For mechanized soybean farming in the tropics, I see no reason why row widths and population densities should deviate significantly from those found to be best in the U.S. However, where hand labor is used to cut individual plants with machetes and to transport plants to a threshing location, yield per plant and conformation of plants may become important factors. One does not necessarily have to sacrifice yield per unit area in order to use low population densities to obatin high yield per plant on tall plants than can be managed easily. Late flowering would increase the height of lowest pods. The plant type visualized for hand-labor production would probably be too tall and lodge excessively at the higher plant populations used for mechanized production in the same locality.

If it becomes important to develop varieties specifically adapted to hand-labor production, this would be a good place for a breeder to incorporate more favorable texture and flavor traits. This statement assumes that these producers should be more likely to comsume whole soybeans than any other segment of the population. However, the soybean will not be atractive as a food source unless seed quality is also very good.

Seed quality may be the factor that determines if the soybean becomes an established crop in some areas. When varieties adapted to temperate regions are grown in the tropics, seed quality may not be good enough for food or for planting seed. The cost of importing planting seed may be prohibitive. Good production and adequate weed control depend on good, uniform stands. Overplanting to compensate for poor germination is expensive and unreliable. Therefore, any tropical breeding program should have good seed quality as one important objective.

Small seeds usually maintain better quality during the maturation process, deteriorate less if harvesting is delayed, and are damaged less during threshing and handling. Thus, small seeded varieties probably would be a more attractive food source, and they will produce better stands at lower seedling rates, because there are more seeds per pound and seeds germinate better.

Soils and Fertilizers:

Soybeans can be grown on almost any soil type that will provide adequate but not excessive moisture. Lime is often needed to produce a more favorable pH and to supply calcium and magnesium. The most favorable soil pH apparently depends on several factors, including the

level of essential elements in the soil. At Gainesville, we measured yield responses on a soil having pH variables ranging from 5.0 to 7.5. At pH values of 5.0 to 6.2, yields were good, but they declined rapidly as the pH increased from 6.3 to 7.5 We did not determine the exact cause of the low yields, but assumed that the high pH influenced the availability of the various essential elements differently, thus creating an imbalance. I should also point out that soybeans produce well on the calcareous soils of southern Florida, which have pH values between 8.0 and 8.5. Thus, there seems to be no pH value that is optimum for all soils. However, for soils that are highly acid in their active state, it is best to add enough lime to raise the pH to 5.5 to 6.0 and to supply adequate calcium. Dolomitic limestone should be used on soils that are low in magnesium.

Fertilizer applications should depend on the level of available elements in the soil and the crop needs. In 1970 I became involved in a project in Guyana to test soybeans on virgin savannah soils that were low in all nutrients. From our experiences in Florida, we estimated that 1500 pounds per acre dolomitic limestone would be adequate. We estimated crop requirements for major elements from North Carolina Agricultural Experiment Station Technical Bulletin No. 197, allowed for some tie-up of phosphorus and some leaching of potassium, and came up with the rates in Table 2. We produced about 35 bushels per acre on soils that produced zero yields in their native state. I do not recommend these rates for all locations, but the procedure for determining rates worked well one time. Perhaps it would work well again.

Inoculation:

Nitrogen is seldom a limiting factor in soybean production if roots are well nodulated with the proper strain of Rhizobium japonicum. It is well established that nitrogen fertilizer inhibits nodulations and nodule activity. However, many observers believe that small amounts of nitrogen are beneficial. Nitrogen does increase root proliferation. I have observed that soybean roots in soil very low in nitrogen are long and have few laterals. Since nodulating bacteria apparently enter roots through root hairs, and root hairs are found only at short distances behind apical meristems of roots, increasing the number of growing points would increase the number of potential nodule sites. Perhaps a small amount of nitrogen fertilizer increases nodule numbers on small plants by inducing more nodule sites. However, one should never apply enough nitrogen to inhibit nodule formation seriously at these induced sites. Unless the soil is very low in nitrogen, it is usually better to apply no nitrogen.

Interactions between Rhizobium japonicum strains and soil environments have been demonstrated. The results indirectly suggest

TABLE 2. Fertilizers and rates used to produce about 35 bushels per acre on virgin savannah soil in Guyana that produced zero yields without fertilizer. 1/

Nutrient	Source	Rate 2/	
		lb /a	kg/ha
P_2O_5	Triple superphosphate	110	123
K_2O	Muriate of potash	240	269
N	Ammonium sulfate	15	17
MgO	Kieserite	16	18
Trace el.	FN 503	15	17
CaO + MgO	Dolomitic limestone	1500	1680

1/ From Hinson, Kuell. Jupiter - a new soybean variety for tropical latitudes. Florida Agr. Exp. Sta. Circular S-217. June 1972.

2/ Except for dolomitic limestone and trace elements, rates are for nutrients rather than sources.

that some Rhizobium strains would be more effective than others in tropical soils. One may reason further that the same strains will not be equally effective in all tropical soils. There is also evidence for Rhizobium strain x soybean genotype interactions. These observations and assumptions suggest the need for Rhizobium strain evaluations on diverse tropical soil types. They also suggest that the final evaluation of strains should be on several diverse soybean genotypes.

It is important that the initial infestation of a soybean production field be with a highly effective Rhizobium strain. It is difficult, if not impossible, to replace an established strain with another strain.

Obtaining good, early nodulation the first year soybeans are grown is a different task. It appears to be more difficult on sandy soils than on fine textured soils. We discussed inoculation procedures and precautions to be taken in the Jupiter release circular, and will not repeat that discussion here. However, I will relate two experiences.

In our initial Guyana work, we planted soybeans in rows with a belt seeder. After seeds were distributed over the appropiate belt length, we covered these seeds with a handful of moist soil that had inoculum mixed with it, then drilled seeds and inoculant into the row simultaneously. Our inoculation rate averaged 10 to 15 times that recommended on the inoculant package and probably ranged from 5 to 30 times the recommended rate. We had excellent nodulation in all rows.

I did not observe the second experience, which concerns inoculating soybeans on sandy soils in central Florida. However, it was reliably reported that careful seed inoculation did not cause young plants to nodulate well. Plants showed severe nitrogen-deficiency symptoms until after flowering and pod-set, then became nodulated and turned green. Few pods were set on these nitrogen deficient plants. Plants did not have adequate mechanisms to compensate for the later, more favorable yield environment; therefore yields were very low. Soybeans planted on the same fields the following year nodulated early and were normal in all respects. This situation was observed repeatedly in a small area of Florida. Dr. Walter T. Scudder of the Agricultural Research Center at Sanford, Florida devises a scheme whereby suspension of a broth culture of Rhizobium japonicum was injected into the soil when seeds were planted. Bacteria were uniformly distributed at high rates, slightly below the seeding depth. This procedure resulted in normal soybeans the first year they were planted. The work was extensive enough to identify inadequate nodulation as the problem in first year soybean field.

These results further illustrate how difficult it is to obtain ad-

equate nodulation the first year soybeans are grown on some soil types. The low yields obtained in the central Florida fields illustrate the consequences of a long delay in nodule formation. The results also suggest that at locations where inadequate nodulation has caused crop failure, it would be better to use the same field location for succeeding trials than to select a field location where soybeans had never been grown.

Mycorrhizal Fungi:

Dr. Norman Schenck and I found mycorrhizal fungi on soybean roots in all fields examined in Florida in 1969. The species prevalent varied as soil environments varied. Inoculating plants with one species increased seed yield 53%. Ross and Harper increased seed yields 29% by inoculating with a species that we did not find in our Florida survey.

In a seminar at Gainesville, a few months ago, Dr. Peter Graham, CIAT, Cali, Colombia, stated that he observed that plants in some rows of soybeans grew much more rapidly than others. His preliminary explanation was that these plants became infected with mycorrhizal fungi earlier than other plants, or possibly to the exclusion of other plants.

Mycorrhizal fungi that colonize soybean roots apparently are widespread in the U.S. However, I have heard several statements to the effect that in fields in which soybeans had not been grown previously, production increased each year for about three successive years. One wonders if this could be caused by a buildup of mycorrhizal fungi that are more compatible with soybeans.

The preliminary explanation of Dr. Graham, if confirmed, suggests that mycorrhizal fungi that are compatible with soybeans are not as plentiful in some tropical soils as they need to be for good production. It may be that they do not exist at some locations. The proper ectomycorrhizal species for certain pine trees apparently did not exist in Puerto Rico until it was introduced. Published information suggests that colonization of soybean roots by mycorrhizal fungi would be particularly beneficial where soils are low in phosphorus.

The introduction of mycorrhizal fungi into production fields, if this becomes necessary, will be a slow and difficult process. These fungi have not been cultured in laboratory media, to my knowledge. Live spores could be introduced to inoculate small soil areas, which could then be used to inoculate larger areas. It could take several years to obtain an adequate buildup, but the potential returns appear great enough to justify this procedure.

Diseases and Insects:

Diseases are almost certain to become serious in any area of intensive soybean culture. Soybean breeders in the U.S. are constantly incorporating disease-resistance traits into new, productive varieties. Many of these same diseases are likely to be serious in the tropics. Resistance to serious tropical diseases should be incorporated into adapted varieties as soon as it is feasible to do so. Tropical breeders can use productive, resistant U.S. germplasm as sources of resistance (when these sources meet the particular need), or they can look for resistance in germplasm adapted to tropical photoperiods. The latter often has poor yield qualities. The most economic transfer of desired traits would generally favor the use of productive, resistant types from the U.S. This assumes that resistance factors from the U.S. would also effect resistance in the tropics. This assumption should be checked for each disease and each combination of genetic factors for resistance.

Breeding for insect resistance is in its infancy in the U.S. Significant progress is expected within a few years. Tropical breeders should follow this work closely in order to take full advantage of desirable germ plasm sources.

Summary:

1. Tropical researchers should concentrate primarily on developing technology that cannot be imported.

2. Photoperiod differences in the tropics are large enough to cause significant changes in plant development.

3. The best situation for the soybean appears to be that it develop seeds when days are shortening. Deviations from this situation can cause abnormal plant development and abnormal maturity.

4. Periods when soil moisture is most favorable for soybean production often do not coincide with the part of the photoperiod cycle that is most favorable for production. Most conflicts should be resolved to favor production when soil moisture is adequate but not excessive.

5. Several varieties with diverse traits will be needed for good production in all photoperiods, growing seasons, and types of farming operations.

6. Soybean production is possible on any soil that can supply proper moisture and nutrition.

7. Nitrogen-fixing bacteria can meet nitrogen needs, but obtaining good nodulation the first year may require special precautions or techniques.

8. It would be well to determine which strains of *Rhizobium japonicum* are best suited to tropical soils and tropical soybean genotypes, and to use only those strains for initial inoculations.

9. Mycorrhizal fungi are potentially very beneficial, particularly on soils low in phosphorus. The species or types most compatible with soybean roots may not be present in some places. Introducing them would be slow and difficult, but rewarding.

10. Diseases and insects are likely to be serious pests in the tropics. Resistant varieties should be developed. U.S. varieties can be valuable sources of resistant germplasm.

BREEDING SOYBEANS FOR TROPICAL CONDITIONS[1]

Luis H. Camacho[2]

El desarrollo de cultivares de soya de buena producción para el Trópico requiere especial consideración debido a que la planta responde a los días cortos. Además hay otras características tales como resistencia a enfermedades, retención de las semillas, la habilidad para germinar en suelos a temperaturas altas que deben considerarse en las variedades para los Trópicos. Las condiciones ambientales en los Trópicos, caracterizadas por temperaturas altas y días cortos, promueven una reproducción rápida y madurez temprana, lo que permite a las variedades tempranas alcanzar la madurez en menos de 80 días y las tardías en alrededor de 100 días. Se presentan datos obtenidos de experimentos realizados en Palmira, Colombia, a una latitud 30N, temperatura promedio de 24°C, altura de 1000 metros y precipitación anual promedio de 1,000 milímetros. Varias características son afectadas por los días cortos, siendo el tiempo de florecida, maduración y crecimiento los más afectados. Variedades tempranas producen menos que las tardías. La necesidad de producir dos o tres cosechas al año, limita el ciclo de crecimiento de las variedades y por ende la producción. Los componentes de producción de fácil medición son características fáciles para distinguir genotipos con propósito de selección.

The development of high yielding soybean varieties for tropical areas requires special consideration due to the response of the plant to short-day photoperiods. In addition, other characteristics such as disease resistance, seed-holding capacity and the ability to emerge from high-temperature soils are esential features to be considered in improved soybean varieties for tropical environments.

Plant breeders in the United States classify soybean varieties according to the latitude of adaptation and are designated as 00, 0, I, II, III, IV, V, Vi, VII, VIII and IX. The lower groups are earlier maturing and are grown under northern latitudes. The higher groups are later in maturity and are adapted to southern regions.

The environmental conditions of the low land tropics, characterized by high temperatures and short days, promote fast reproduction and

1. Contribution from the Colombian Institute of Agriculture (ICA).
2. Grain Legume Breeder, ICA. Palmira, Colombia S. A.

early maturation, thereby enabling the early varieties to reach maturity in less than 80 days and late ones in about 100 days.

Data presented in this paper came from experiments conducted in Palmira, Colombia, at a latitude of 3°N, average temperature of 24°C, altitude of 1000 meters, and average annual rainfall of 1000 milimeters.

Vegetative and Reproductive Growth under Tropical Environments.

Several plant growth characteristics were affected by the short-day photoperiod of the tropics. The most striking effects were on time to flowering, maturity and plant height.

Table 1 presents data on 10 U. S. varieties belonging to different maturity groups compared to a variety adapted to commercial planting in Colombia. As expected, varieties of lower maturity groups were earlier than those of late maturity groups. There appeared to be a correlation between days to flowering and days to maturity, indicating that as varieties delay the period from emergence to flower, more time is required to reach maturity. Reproductive period in this paper is taken as the time elapsed between flowering and maturity. This trait does not seem to be positively associated with flowering in all varieties. A comparision of two traits in Adelphia and Hardee varieties indicated that the period of dry matter accumulation in the seed (bloom to maturity) may be the same in early and late varieties. Plant height was not related to earliness as early varieties like Harosoy 63 or Hark were as tall or taller than the later varieties Hardee or Davis. Also, varieties of similar maturity like Hardee and Improved Pelican may be quite different in plant height.

Data comparing the growth of varieties under temperate and tropical environments are presented in Table 2. When planted in late June at the latitude of Stoneville, U. S. A., Hardee variety flowers in 63 days and matures in 147 days after emergence, thereby allowing a reproductive or pod filling period of 84 days (Hartwig, 1970). Harosoy variety planted in May at the latitude of Ames, U. S. A., takes 51 days to bloom and 113 days to maturity with a reproductive period of 62 days (Hanway and Weber, 1971). These two varieties reach the flowering stage in Palmira, Colombia in less than half the time required to reach the same stage in temperate zones. The length of the reproductive stage, or pod filling period, is not so drastically reduced in the tropics but it still may be less than 80 per cent of the period required in the adaptation area of a particular variety.

A short growing season from emergence to flowering may result in insufficient leaf area development, low photosynthate production and presumably low pod set. In addition, if the time of pod filling is short,

Table 1. Some characteristics of soybean varieties grown in Colombia at a latitude of $3^{o}N$.

Variety	Maturity Group	Emergence to bloom. Days	Emergence to maturity. Days	Bloom to Maturity. Days	Plant Height. cm.
Hark	I	21	73	52	38
Harosoy 63	II	22	72	50	35
Adelphia	III	24	84	60	36
Clark 63	IV	24	79	55	42
Hill	V	29	86	57	35
Davis	VI	29	95	66	34
Semmes	VII	29	89	60	32
Hardee	VIII	31	91	60	35
Im. Pelican	VIII	30	87	57	78
Jupiter	IX	34	99	65	75
ICA Lili	---	31	94	63	70

Table 2. Duration of vegetative and reproductive periods of growth of two soybean varieties under tropical and temperate environments.

Variety	Emergence to bloom. Days			Bloom to maturity. Days		
	Colombia	U. S. A.		Colombia	U. S. A.	
	Palmira	Stoneville*	Ames**	Palmira	Stoneville*	Ames**
Hardee	31	63	---	60	84	---
Harosoy	22	--	51	50	--	62

* Planted 20 June according to Hartwig (1970)
** Planted 16 May according to Hanway and Weber (1971)

early vigorous growth and accelerated rate of dry matter accumulation in the seed would be required to produce significant seed yield in tropical varieties. Studies conducted in the United States by Egli and Legget (1973) indicated the existence of variability in the rate of dry matter accumulation between varieties.

Yield in Relation to Maturity

Table 3 presents yield data of varieties of different maturity groups grown in Palmira in 1972 and 1973. It is evident from this data that varieties of groups I to IV show low yield potential, while varieties of late maturity groups show seed yield of over 2000 kilograms per hectare with a more prolonged pod filling period (Table 1). This agrees with the results of Egli and Legget (1973) who found that the effective period of dry matter accumulation in the seed was positively correlated with seed yield in kilograms per hectare.

The need to farm the tropical land during two and sometimes three seasons per year limits the growing cycle of varieties. As stated before, sufficient leaf area should be present before floral initiation and quick and efficient accumulation of dry matter in the seed must follow in order to produce significant yields at a proper time of harvest that facilitates planting the following crop.

Varieties fitting the above model could be developed provided the proper variability is found in existing genotypes. Three types of varieties could be developed with no change in length of the growing season: Variety type 1. Varieties with early vigorous growth that would take about 35 days from planting to bloom, 60 days from bloom to maturity and 10 days from maturity to harvest. This model fits the present adapted varieties with the additional feature of early vigor that provides more leaf area before bloom initiation. Variety type 2. Varieties that take about 45 days to bloom, 50 days from bloom to maturity and 10 days from maturity to harvest. Varieties fitting this model would have a short period of pod filling.

A search for the above discussed growth characteristics was initiated in Colombia in a group of 145 late maturing varieties received from Dr. E.E. Hartwig of Stoneville, Mississippi. Table 4 presents correlations and other parameters of these varieties. A positive correlation was found to exist between days to bloom and days to maturity but the former appears to be independent of the pod filling period. This would facilitate the selection of late blooming genotypes with a short period of pod filling. The strong association between emergence to maturity and bloom to maturity can be explained by the fact that the latter character is a component of the former. Correlations between

Table 3. Yield of varieties of different maturity groups and a local commercial cultivar grown in Palmira, Colombia.

Variety	Maturity Group	Yield Kg./Ha.		
		1972	1973	Mean
Hark	I	1389	1470	1429
Harosoy	II	1775	1376	1575
Adelphia	III	1731	1558	1644
Clark 63	IV	1305	1689	1497
Hill	V	2142	2155	2148
Davis	VI	2589	2384	2486
Semmes	VII	2166	1977	2071
Hardee	VIII	2964	2390	2677
Imp. Pelican	VIII	2461	2655	2558
Jupiter	IX	2689	2320	2504
ICA-Lili	---	2684	2741	2712

Table 5. Components of yield in different varieties per meter of row.

Variety	Plant No./m.	Branch No./m.	Pod No. in branches/m.	Pod No. in c. stem/m.	Yield g/m.
Kark	16-20	30	64	227	1100
Williams	19-24	25	46	286	1600
Imp. Pelican	18-20	57	236	400	2000
Davis	17-29	79	246	251	2300
ICA Lili	16-19	67	251	267	2100

lodging and growth characteristics tended to be negative and relatively weak.

Selection for growth characteristics should be relatively easy to conduct under tropical environments because of the stability of certain environmental factors, i.e., daylength and temperature, which allows the growing of progenies any time during the year with a relatively constant environmental effect. Also, these characteristics appear to be controlled by few genes and show relatively high heritability. In populations of a cross between late and early varieties, Camacho (1973) found that about 50 percent of the phenotypic variance was of the additive type for the traits, days to bloom and days from bloom to maturity.

Components of Yield

Easy measurable components of yield are useful characteristics for distinguishing genotypes and for selection purposes. Some of the physical components of yield that can be identified in soybeans are: number of branches, number of reproductive nodes, number of pods per reproductive node, number of seeds per pod and seed size. The relationship of yield with its components varies according to plant competition and genotype. For example, when grown at a spacing of eight plants per meter, ICA Lili and Hill varieties have six branches per plant but when grown at a spacing of 50 plants per meter of row, Hill has 1.6 branches per plant whereas ICA Lili has only 0.2 branches per plant (Bastidas et al.).

A comparison of yield components in different varieties is presented in Table 5. Varieties were planted at a spacing of 60 centimeters between rows and four centimeters between seeds. Samples of one meter section were taken at harvest for yield components and the number of plants per sample was recorded. It is interesting to note the difference in branching ability as the adapted varieties were intermediate to profuse in branching whereas unadapted ones had very low branching ability. Branches contributed about 50 percent of the total number of pods in Davis and ICA Lili, 38 percent in Improved Pelican, 22 percent in Hark, and 14 percent in Williams. Considering these components, it can be seen that yield is positively correlated with branching and pod number, indicating that branching ability should be considered as an important trait when selecting varieties of high yield potential for tropical environments. Poor plant stand is commonly observed in soybean fields of tropical areas; since high branching varieties may have the ability to compensate for poor plant stand by producing more branches per plant under low plant competition, it may be desirable to breed for this trait in tropical areas.

Table 4. Simple correlations, means and coefficient of variation for four growth characterics in late maturing soybeans grown in Colombia.

Characters	Correlation coefficient	Mean of Character	C.V.
A and B	0.52	A = 45	(C.V.) A = 19
A and C	-0.04	B = 105	(C.V.) B = 11
A and D	-0.27	C = 62	(C.V.) C = 11
B and G	0.86	C = 3	(C.V.) D = 38
B and D	-0.11		
C and D			

A = Emergence to bloom (days). B = Emergence to maturity (days)

C = Bloom to maturity (days). D = Lodging (score 1 to 5)

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OFF-SEASON NURSERIES

C.A. Brim 1/

El uso de semilleros fuera de época, por el Departamento de Agricultura Federal, surgió como resultado del programa de fitomejoramiento de la soya para resistencia al nemátodo de quiste. El uso de semilleros durante la época de invierno sirvió para aumentar la semilla de líneas con resistencia al nemátodo de quiste y de esta forma estabilizar la producción de soyas. En este trabajo se discuten varios sistemas de fitomejoramiento que se utilizan en los semilleros fuera de época. Estos semilleros proveen la flexibilidad adicional necesaria para aumentar la eficiencia de varios métodos de fitomejoramiento. Además sirven para aumentar rápidamente las líneas o material que se necesite cuando surjan problemas de enfermedades, insectos o nemátodos en las regiones templadas.

The use of off-season nurseries for USDA breeding programs was an outgrowth of experience gained while developing a soybean cyst nematode (SCN) resistant variety. The nematode was first recognized in the U.S. at Castle Hayne, N.C. in 1954. This disease is devastating to soybeans and appeared to present a potential threat to the industry in the southern United States.

As it turns out cyst nematode infestations reduce optimum production on several million acres in North Carolina, Tennessee, Missouri, and Arkansas. Infested soils are also found in eight other states from Florida to Illinois. Resistance to SCN was discovered in 1957 and a backcrossing program was initiated. As the program of transfer of resistance to adapted varieties reached a conclusion it became obvious that "off-season" seed production would reduce the time needed to get seed of the resistant variety to producers. In 1964-65 approximately one acre of Pickett (Resistant to SCN) was increased in the South Field here at the Federal Experiment Station, Mayaguez, Puerto Rico, and the over 40 bushels of seed produced was distributed to seven southern states. This was increased from about 35 pounds of breeders seed. Thus, the winter nursery served an extremely useful role in increasing a line urgently needed to stabilize production.

1/ Soybean Production Research USDA - N. C. State University, Raleigh, N. C.

The response of soybeans to day length is well known. In short days, and at reasonably high temperatures, the soybeans tend to flower within 30 days after emergence.

These environmental conditions prevail at lower latitudes and are very similar to the environments provided by greenhouses in temperate climates.

Many soybean breeders are using a modification of the pedigree method of selection for advancing limited numbers of populations in greenhouses. The modification is based on the finding that additive genetic variance comprises the greater portion of total genetic variance for most quantitatively inherited characters in soybeans. With only additive genetic variance and obligate inbreeding, the means of the inbred generations remain unchanged and the among-progeny variance increases while the within-progeny variance decreases. It has been shown that inbreeding to the F_4 or F_5 generation before testing would be the most efficient procedure.

Thus, it is of interest to reach the F_4 or F_5 generation as rapidly and as efficiently as possible.

The method, commonly referred to as single seed descent, results in a set of essentially random lines from a cross each of which trace to a different F_2 ancestor. The lines are obtained by advancing only a single seed from each of the individual plants in the population. The principle advantage of the method is that genetic variance can be maintained for characters that are not amenable to visual discrimination. The operational ease of advancing segregation populations is also an advantage; less space is required compared with progeny rows, record keeping is reduced to a minimum (a single pod from each plant constitutes all the identification necessary), and harvesting is easily done. Selection among individual plants for simply inherited traits or traits with high heritability can be conducted at any stage of inbreeding. Selection for simply inherited traits should be delayed until higher levels of inbreeding are reached since the number of individuals available increase as a result of the inbreeding process. For example, at higher levels of inbreeding approximately equal numbers of plants are homozygous for flower color whereas in the F_2, only 50 percent of the plants are homozygous. Since only a single pod from each plant is necessary, the reduced vigor of plants grown in short days is not a problem. In fact, the response to short days is an advantage since the time required per generation is about 12 weeks. It is apparent that winter nurseries are particularly useful in advancing large numbers of populations as quickly as possible.

It should be noted that for a very limited number of populations,

greenhouses could substitute for the winter nursery. However, the winter nursery could be used for many populations since the space requirements are very low.

The use of a winter nursery can reduce the time needed for advancing the generations to the testing stage by two years. Furthermore, an additional generation of inbreeding is obtained. With very intensive management, F_4 progenies could be tested in the mainland U. S., the third season after the cross is made, thereby reducing the time by one-half. However, the space demands in off-season nurseries would be increased since in the F_4 progeny rows rather than single plants would have to be grown in order to provide sufficient seed for testing the lines.

The single seed descent procedure is adapted to tropical soybean breeding programs where the crop can be grown the year round.

The method outlined above takes advantage of an environment particularly suited to a specific breeding method. However, other procedures do not work as well because of the reduced vigor of plants which are grown in October to April plantings at lower latitudes north of the equator. Seed production is greatly reduced under these short day conditions. The hazards can be overcome with supplemental lighting. Supplemental lighting at Mayaguez has provided an ideal solution to the requirements for other breeding procedures as well.

For example, the time required per cycle of selection is a primary issue in recurrent selection procedures. Minimizing cycle time in soybeans is extremely dependent on the amount of seed which can be produced on single plants during the off-season. To clarify this: Recurrent selection is used to develop improved populations and involves intermating selected parents to provide a test population for choosing the parents for the next cycle of selection. In soybeans, as you know, only one or two seeds are obtained per cross. Thus, cycle time in recurrent selection is extended compared with corn, tobacco, sorghum and so on, because an additional generation is required per cycle. The additional generation is needed so that sufficient seed from the crosses can be obtained for progeny tests. It is on the basis of the progeny test that parents are selected for the next cycle of intermating. In soybeans then, each cycle of selection requires three years compared with two years with many other crop species. Cycle time can be reduced, however, by growing the selfing generation in the off-season.

It is critical to the procedure that maximum seed production be obtained. For example, yield testing of soybeans requires multiple row plots because of the bias which arises from intergenotypic competition. Even if small plots are used, a minimum of 250 seeds per F_1 plant is

required. Thus, supplemental lighting, especially in the lower latitudes north of the equator, is a must for optimizing seed production.

I should note also that the discovery of a genetic male-sterile is extremely useful in recurrent selection. There is likely to be an increase in the use of recurrent selection in soybeans now that a male-sterile is available. The male sterility is a result of pollen inviability.

The male sterile plants retain their leaves past usual maturity. The interjection of the male-sterile trait into populations reduces the tremendous effort needed to intermate selected parents by artificial means. Seed on male-sterile plants result from natural hybridization. Although the seed set on the male sterile is considerably reduced, essentially all are a result of natural crossing. Furthermore, once the male sterile is introduced it is automatically retained in the population. Details of this procedure were recently published in Crop Science and will not be discussed here.

Double cropping soybeans and small grain is a common practice in the southeastern U. S. Soybeans are planted following wheat as late as mid-July in North Carolina. The first frost usually occurs around November 5th. Expected yields of late planted soybeans are well below those of early plantings. All phases of the growth cycle are compressed and yields are considerably reduced as planting dates are delayed. One of the factors involved in low yields is the reduced vigor encountered in late planting when days are short and temperatures are high. This is characteristic of determinate types of soybeans. Compared with indeterminate types, determinate soybeans accumulate 67 and 84 percent of their final dry matter and height, respectively, at flowering. Only a few nodes, 3 to 5, are added after flowering in determinate types. Indeterminates continue to grow after flowering and attain about 70 percent to their final dry matter and over 30 percent of their final height after the onset of blooming.

The reduced vigor encountered is compensated for, in part, by adjusting population density. Yields can be improved by reducing row width and increasing number of plants per foot of row.

It occurred to us that production may also be improved if flowering could be delayed. Of course, other traits which could be considered would include the ability to produce increased vegetative growth quickly. One week of additional vegetative growth, especially during periods of high temperatures, could perhaps improve yields considerably. For example, as a general rule of thumb, in North Carolina one can expect a reduction of one bushel per acre for every day that planting is delayed after July 1.

It has been shown that variability exists in the germ-plasm collection for response to photoperiod. At Mayaguez, for example, PI 274,454 flowers about 100 days after planting, compared with 35 to 47 days for U. S. varieties. At 3° latitude (12 hr. day) PI 274,454 flowers in about 65 days. Crosses were made to the plant introduction and segregation populations were grown under 12 hr. days in the phytotron at N. C. State University. The latest flowering plants were then backcrossed to U. S. types and the cycle repeated. We are now cooperating with Dr. Stone here at Mayaguez on this program. The environment at Mayaguez is especially suited for the selection required because of the range in photoperiod. An added advantage over the phytotron is that we can obtain maturity data on the populations. Although the program is in the initial phases, we appear to have been successful in extending days to flowering for as much as three weeks depending on day length.

From our results thus far, response to photoperiod has been shown to be heritable. A primary issue is the effect of selection for delayed flowering on maturity. Too much of a delay in maturity would be unsuitable for southern U. S. production and for continuous cropping that might be practiced in the tropics.

On the average, the selected lines are within the maturity range needed in southern U. S. Compared with Jupiter, these lines mature considerably earlier in June and July plantings. Vegetative growth was also increased campared with Hampton.

If one compares the performance of Bragg at Mayaguez and Raleigh it is apparent that under the shorter day flowering is earlier and height at maturity is considerably less. If maturity can be maintained at about 120 days, would the increase in vegetative growth be an advantage in tropical production? The fruiting period would obviously be compressed. This may be a big disadvantage since surely the ability of the plant to respond to varying environmental deficiences would be lessened.

In summary, off-season nurseries play a vital role in U. S. breeding programs. These nurseries provide the additional flexibility necessary to increase the efficiency of various breeding procedures. They provide a means for rapid increase of urgently needed lines when and if the need arises. The benefits which can accrue to soybean production for both tropical and temperate areas rest on our ability to work cooperatively on problems of mutual interest.

SPECIAL BREEDING AND EVALUATION TECHNIQUES FOR SOYBEAN IMPROVEMENT

F. K. S. Koo 1/
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La presente revisión cubre las áreas de técnicas especiales de hibridación empleadas en Glycine max (L.) Merrill tales como hibridación mutagénica, selección recurrente y usos de la heterosis así como técnicas especiales de selección y evaluación para determinar la resistencia a enfermedades e insectos, alto contenido de proteínas, metionina y otros amino acidos que contienen azufre, fotoperíodo neutral, fotorespiración baja y germinación alta a temperaturas elevadas. Se ha enfatizado la discusión de las técnicas más útiles al programa de mejoramiento de la habichuela soya en el trópico.

The soybean is unique in that it is an oil crop as well as a protein crop. Basically the soybean is a protein crop owing to the fact that its seed contains over 40% protein and some 20% oil. For centuries, soybeans have been consumed by Asian people mainly as a source of protein in their daily diet.

The soybean is generally considered as a crop best adaptable to temperate zones but is has been grown also in many tropical regions of southeastern Asia, India, Africa, Caribbees and Central and South America.

The world yield of soybean in the past two decades has shown a phenomenal increase which is attributable mainly to the increase in acreage in the USA where two-thirds of the world's crop is now prod uced. However, since 1950, soybean yield per acre in the USA has increased just over 1% per year in contrast to nearly 4% per year for corn. In the opinions of many investigators, the soybean yield potential may have reached a plateau or nearly so. It appears that further improvement which we are seeking might be achieved by a breakthrough in varietal improvement with infusion of new germplasms on a much broader base and in the application of ingenious approaches in breeding. We working in the tropics seem to have additional tasks to perform,

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i.e., to work from the base line up because the soybean is a relatively new crop to these regions and we must adapt the crop to our special tropical conditions and improve it to meet our special needs.

In this presentation I plan to show what special breeding techniques are available and also what special methods for evaluating the breeding materials can be used to achieve a specific goal, and if I can I shall point out the merits and shortcomings of the methods.

1. Special breeding techniques

There are only a limited number of techniques such as mutation breeding, recurrent selection, possibly utilization of F_1 hybrid vigor, etc., that may be regarded as special breeding techniques in a strict sense. Various other approaches for combining parental materials, for advancing generations and for making selections commonly employed in the conventional breeding programs are not special breeding techniques. Also many special methods for breeding for disease and insect resistance or for improving crop quality are just techniques for evaluation.

Mutation breeding

Mutation breeding differs from the conventional breeding technique only in one respect, i.e., the genetic variability exploited in the former is obtained by artificial induction through the use of physical or chemical mutagens, whereas the variations used in the latter are already existing in the breeding material or generated through genetic recombination. The procedures used in both methods for selection, performance testing, etc. are essentially the same.

Mutation breeding has its limitations but it also has certain merits that should not be overlooked. Mutation breeding may help to create a variety with disease resistance never known to exist in nature previously, as in the case of peppermint Verticillium wilt resistance (Murray, 1969), or to change the environmental adaptation of a new variety so it can be grown in new regions as in the case of Mari barley (Gustafsson, 1963). According to the survey conducted by the IAEA (Sigurbjorsson, 1972), over 90 varieties have been developed from mutation breeding directly or indirectly, and about two-thirds of these have been released in the past decade or so. Of 15 leguminous varieties, four are soybean varieties. The total acreage under which the mutant varieties are cultivated, as a conservative estimate, would amount to 3-6 million hectares with a commodity value of 750-1,500 million dollars.

In a review paper (Koo, 1972) on soybean mutation breeding pre-

sented in the IAEA Symposium, I mentioned that the work on soybean improvement through mutation breeding in the past 20 years has been rather limited but the prospect for new advancement in varietal improvement through the uses of this special tool appears bright. In the past, attempts have been made to improve yield, maturity, protein and oil content, quality, etc., but it appears this technique could be used to our advantage in improving disease resistance or methionine content, or in eliminating or reducing the linolenic acid or photorespiration.

In the experiments conducted by various investigators, X-rays, gamma-rays and neutrons have been used. Also chemicals such as EI and EMS have been tested. The optimum X-ray doses for mutation induction are 10-12 krads. The appropriate gamma ray dose is around 15 krads; thermal neutrons, in a range of 3-7 x $10 N_{th}/cm^2$; and fast neutrons, about 1.5-2.0 krads. For more information on mutation induction, uses of various physical and chemical mutagens, their efficiency and the modifying factors, handling of treated materials and progenies, etc., you are referred to the book "Manual on Mutation Breeding" compiled by the IAEA (1970).

Recurrent selection

The use of recurrent selection in a broad-based genetic population has been restricted in general to cross-pollinated species. Difficulties inherent in artificial crossing and low seed set per cross may have limited its application to many self-pollinated species. Recent discovery of several genetic male-sterile stocks in soybeans would afford an opportunity to adapt recurrent selection procedures to the improvement programs. The stock of Brim and Young (1971) has virtually complete pollen sterility, and the other found by Caviness and Fagala (1972) shows complete male sterility under the day temperature of 35°C.

Brim and Stuber (1973) have outlined a procedure for the synthesis of population and the basic selection scheme. They suggest that the basic population be synthesized in several forms such as two-way crosses, backcrosses, and diallel crosses. To minimize the contribution of the cytoplasm from the male-sterile source, heterozygous fertiles from a maintainer line may be used as male parents in the synthesis of the initial population by hand pollination. Also the genetic contribution of the male-sterile genotype may be minimized by backcrossing. Before selection is initiated, several cycles of intermating are recommended. The basic scheme is outlined as follows:

Generation 1 - Allow natural pollination to intermate population segregating for male sterility.

Generation 2 - Advance (by natural selfing) progenies of male-

sterile plants from Generation 1 to provide adequate seeds for field testing.

Generation 3 - Test progenies of male-fertile plants produced in Generation 2. Composite remnant seeds from parents of selected progenies or seeds produced by male-fertile plants in the selected progenies to provide parents for next cycle of intermating.

They also suggest modifications for the basic scheme. For instance, selection for highly heritable plant traits such as disease and insect resistance or seed quality might be accomplished even in Generation 2. The requirement for additional generation for selection stems from the fact that traits under selection in the previous generation may have been evaluated in the male-sterile phenotype and the results might be misleading.

Use of hybrid vigor

The use of heterosis to improve crop productivity has been exploited to the very limit in open-pollinated crops. However, this technique appears less applicable to self-pollinated crop plants. The difficulty involved in its application to soybean may lie in: a) lack of appropriate male-sterile stocks and b) non-availability of methods for producing commercial hybrid seeds.

Weber, et al. (1970) observed heterosis in the F_1 hybrids of 85 soybean crosses. The hybrids gave an average of 13.4% heterosis for seed yield over their respective high parent in the crosses evaluated. Nearly 77% of the hybrids exceeded the high parent yield. The increase in seed number was largely responsible for the increase in seed yield of the F_1. The hybrids with the midparent average in maturity were generally shorter than the taller parent and were not significantly different from the midparent mean in protein and oil contents. Specific combining ability effects were significant for seed yield, maturity date, plant height and oil content. Except for oil content, general combining ability estimates were significant and were 2-6 times larger than specific combining ability effects.

In view of these findings, soybean yield improvement through the use of hybrid vigor may be achieved if appropriate genetic male sterility stocks are found and procedures for economically producing hybrid seeds are developed.

2. Special evaluation techniques

Special techniques available for evaluating the breeding material for various purposes are too numerous to be discussed here. Due to limited time, I shall present the ones which I believe are pertinent to our specific breeding objectives.

Techniques developed for mass-screening breeding lines must be simple, easy to perform, less time consuming, inexpensive, and of high sensitivity and precision.

Screening techniques for disease and insect resistance

Disease and insect problems in the tropics have been very troublesome. One of the ways to insure the soybean yield potential is to breed for resistant varieties. There are many techniques known to be highly effective in detecting and isolating desirable resistance to a particular disease or insect. Here I shall discuss only a few important ones for illustration.

In the breeding program for resistance to the disease *Phytophthora* rot which is particularly troublesome on heavy clay soils, Hartwig (personal communication) grew his F_3 lines in pots with sand in the greenhouse. Seedlings at about tne first trifoliate stage were inoculated individually by inserting the spear-pointed needle with slushy culture of *Phytophthora* into the hypocotyl of the plants. To prevent the inoculum from drying, a mist of water was applied over the seedlings on the bench to keep the humidity high. Seedling reactions were identifiable in about three days. Resistant and segregating lines were noted and then these selections were grown for confirmation on clay soil under natural field infection by Phytophthora rot. Further tests were again made in F_4 and F_5 under fields conditions.

Screening for resistance to the foliar disease bacterial pustule caused by *Xanthomas phaseoli* var. *sojensis* is generally conducted in the field under artificial epidemics, which can be easily created by spraying the leaves of the highly susceptible varieties with a fine mist consisting of a water suspension of the bacteria (Laviolette *et al.*, 1970). Susceptible varieties are grown as borders and in the rows at intervals throughout the disease nursery. Consistent good results can be obtained by pressurized spray during the middle of the day. A total of three inoculations should be made at 10-day intervals, beginning when the plants are 25-30 cm tall. The inoculum can be increased in Weenham's buffered potato dextrose broth at room temperature for 3-5 days and diluted with water for use.

Mexican bean beetle (*Epilachna varivestis* Mulsant) is one of the most destructive pests. Genotypes resistant to this insect have been observed in the studies with the soybean world collections for the

southern regions of the United States (Van Duyn et al., 1971, 1972). Techniques (Van Duyn et al., 1971) used for screening for resistant varieties include: a) counts of adults and larvae collected on a canvas by beating the plants in a unit area, b) counts of egg masses on the plants (underside of the leaflets), c) foliage loss estimates, and d) laboratory non-choice feeding test using leaf sections placed in Petri dishes. Van Duyn et al. (1972) also devised other methods to investigate in the laboratory a) possible preferencial responses of adults and larvae when fed only resistant or suceptible foliage and b) drop-off rates of first instar larvae from foliage of resistant and susceptible genotypes.

Protein determination

To improve the protein content is one of the major breeding objectives for soybeans in the tropics. Several techniques are available for mass-screening breeding lines for higher protein content.

The standard Kjeldahl method (AOAC, 1970) has been conventionally used for the determination of nitrogen content of plant material from which the protein content is calculated. For small samples, the micro-Kjeldahl method (AOAC, 1970) is often used to great advantage. In certain cases single seed analysis may be made with this technique (Singh et al., 1969). The Kjeldahl is a time-consuming technique but it has been accepted as the basic method for protein determination.

A simple and fast method has been developed by Hartwig and Collins (1962) for estimating protein content in soybeans. Based on differences in density of the oil and non-oil portions of the seed, the oil content in the seed can be estimated by density classification with glycerol-water solution. Since the protein and oil contents in soybean seed are highly negatively correlated, one can select the seed rich in protein simply by saving the seed low in oil. This technique can be effectively used for preliminary screening to increase the frequency of plant progenies with high protein.

Exploiting the same fact of negative correlation between the protein and oil contents, the nuclear magnetic resonance technique (Hartwig, 1969) which is rapid and non-destructive, has been used to estimate indirectly the protein content by determining the oil content.

The dye binding method (Mossberg 1969) for bulk samples and the micro-dye-binding method for single seed (Kaul et.al., 1970) have been successfully employed for small grains and some legumes. In the process, seed protein reacts with monosulfonic azo dye, acid orange 12, to form an insoluble complex. The estimate of protein from a conversion table is based on colorimeter measurement of unbound dye

through its relationship to total nitrogen as determined by a standard procedure such as the Kjeldahl. It is known that the values from the measurement with this method can be strongly affected by heat, or by the content of fat and oil. Recently, Hymowitz et al. (1969) have improved the technique for soybean protein determination. They are of the opinion that the modified dye binding method might prove to be better than the Kjeldahl because it actually measures protein nitrogen only. They also have found the adverse effect of high temperature for meal drying on measurement.

Methods using more sophisticated equipment have also been explored. Neutron activation of nitrogen-- 14N (m2n) 13N reaction-in the plant material (Kosta et al., 1969; Wood, 1972) has been used for estimating protein content. The results show a very good agreement with standard Kjeldahl determination. Also nitrogen can be determined by direct nuclear reaction -14N(p, d)13N (Johansson et al., 1969), or by X-ray photoelectron spectroscopy (Klein and Kramer, 1970). However, the facilities needed for the determination are generally not available to plant breeders. So the applications of these techniques are limited for the time being. Besides, these methods need further standardization and improvement.

Determination of methionine and other S-containing amino acids

High nitrogen value or protein content per se may not be indicative of the quality of the seed protein, as it is shown with soybean protein which has less than desirable amounts of several essential amino acids, including methionine and cystine.

The classical standard method for methionine determination using colorimetry, developed by McCarthy and Sullivan, is based on the specific color complex formed with nitroprusside (Horn et. al., 1964). The more elaborate and accurate method is the ion-exchange chromatography (Moore and Stein, 1963) which may be used only for limited number of determinations.

The microbiological assay using either *Streptococcus zymogenes* (Kelly et al., 1970) or *Leuconostoc mesenteroides* (Difco, 1964), although less precise, can yield very informative results in the hands of experienced investigators.

At PRNC, technique employing both isotopic dilution and neutron activation principles for methionine determination is being developed by S. N. Deshpande. The method consists of hydrolysis of protein in seed meal, removal of electrolytes from the hydrolyzates, isotopic dilutions with 14C-labelled methionine, separation by thin-layer chromatography or thin-layer electrophoresis, and assay of the radioac-

tivity of the labelled material by liquid scintillation counting. The specific activity is determined by measuring the intensity of the isolated spot containing the amino acid by reflectance densitometry. This nuclear technique is far more sensitive than the classical colorimetic technique. A sample of soybean meal as small as 50 mg can be used for the assay. Further improvement on the technique for determining the specific activity has been explored with neutron activation of the mercuric and silver derivatives of methionine (or other S-containing amino acids).

Gas liquid chromatography has been used to aid determination of methionine content of plant material. Two methods receiving the most attention use either trimethylsilyl (TMSi) derivates or N-trifluoroacetyl O-n Butyl ester (TFA-butyl) derivatives (cf. Hardy and Kerrin, 1972, for Gehrke's works). The former is less desirable because the TMSi derivatives are hydrolytically unstable. Also it takes longer time for determination. In contrast, the TFA-butyl esters are more stable to hydrolysis, and GC determination times are on the order of 30-45 minutes, but two different GC columns are required to separate 20 amino acids. A third method has been developed by Hardy and Kerrin (1972) in which the volatile N-trimethylsilyl-O-butyl ester (TMSi-butyl) derivatives of 20 amino acids can be separated in less than 35 minutes on a lightly loaded textured glass bead gas chromatographic column.

Recently, an automated colorimetric method using the Technicon Autoanalyzer has been perfected by Gehrke and Neuner (1973). The color reaction and the color intensity are determined at 526 nm. The colorsystem manifold was optimized for each phase of the reaction procedure with respect to volume flow rate, concentration of reagents, time, and temperature. To practically eliminate interference from other amino acids, papain is used for partial enzymatic hydrolysis at 50°C for 4 hours which drastically reduces the total number of free amino groups available for complexing with nitroprusside, while at the same time providing enough fragmentation of the protein to peptides to permit a quantitative reaction with the exposed sulfur of methionine. There is no interference from cystine and cysteine as CyS_2 and CySH complex with ferricyanide is unstable and breaks down in a 6-minute time delay coil in the Autoanalyzer. The analytical precision and accuracy of the method have been proven by repeated independent analyses of samples of corn, mungbean and soybeans, and the results are comparable to those obtained by the ion-exchange method. This method appears to be the best method so far and it has the speed. The papain-hydrolyzed samples can be analyzed at a rate of 20 samples per hour.

The total S-containing amino acids including cystine are of great importance in the diet. The methods developed by Deshpande and the

gas chromatographic analysis could be used to determine both methionine and cystine. It may be useful to determine total sulfur content if it represents a direct measure of methionine and cystine in the seed protein. Recently, Reed (1973) in Australia has developed a rapid, sensitive and precise technique using X-ray fluorescence spectroscopy for total S determination. It takes only two minutes reading time for each sample. The method has been applied to analyzing samples of various crop plants, including forage legumes, and the results are in extremely good agreement with the chemical results.

Screening for day-neutral type

In the tropics it may be advantageous to grow soybean in the winter under lessened temperature stress if the day-neutral varieties are available. The adaptable photoperiod-insensitve types may be induced by mutagenic treatment of sensitive varieties. Isolation of the day-neutral mutants can be achieved in two steps, first by selecting the late flowering and/or late maturing variants in the mutagen-treated progenies, then by growing the late selections in the winter. The true day-neutral types will not flower and mature early as the sensitive type does because they will not be affected by short photoperiod. Mutants of this type have been obtained in our mutation breeding program at PRNC (Koo *et al.*, 1970, unpublished).

Screening for photorespiration-deficient type

The soybean is a photorespiratory species which consumes, with no known function, about 15-50% of the total CO_2 fixed in the plant by photosynthesis. If photorespiration can be spared, the energy which would be lost in the process may go into increasing growth and yield. Widholm and Ogren (personal communication) have initiated a mutation breeding program with the sole purpose of inducing photorespiration-deficient mutants. The mass-screening technique involves growing soybean and corn plants in a 4:1 ratio up to two weeks of age and then subjecting to test under continuous illumination in a sealed, air-conditioned 7 x 15 feet chamber. Soybean plants with regular photorespiration rate will senesce in a week as a result of net CO_2 loss but the mutants with reduced photorespiration rate (say at 30ppm CO2) will survive. To date, some 100, 000 gamma- or neutron-irradiated and 50, 000 EMS-treated M2 seedlings have been screened but so far no desirable mutants have been recovered.

Evaluation for seedling emergence ability

Selection for strains with excellent seedling emergence in the field planting is important in a breeding program, especially in the tropics. The IITA (1972) in Nigeria has reported poor seedling emer-

gence at the start of the first rainy season (April) due to high temperature of the soil; the top 5 cm soil often exceeding 40°C several hours a day. Laboratory test at 32°C has produced vigorous normal seedlings but has failed to produce normal seedlings at 37°C. Elongation inhibition of hypocotyl and radicle and bacterial rotting at high temperatures appear to be the cause for poor emergence. Similar problems have been encountered by other investigators in the USA (Gilman et al., 1973; Grabe and Metzer, 1969) but at lower temperatures. Apparently there is varietal difference in the ability to germinate and emerge at the elevated temperatures. Burris and Gehr (1971) have suggested the paper towel method for screening for strains tolerant to high temperatures.

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EXPERIMENTS ON THE EFFECTS OF SOIL ACIDITY, SEASON AND SPACING ON YIELDS OF SOYBEANS UNDER HUMID TROPICAL CONDITIONS 1/

by J. Vicente-Chandler, and Servando Silva 2/

Se determinó el efecto de la acidez del suelo, época del año y espaciamiento en la producción de habichuelas soyas de la variedad Hardee cultivadas intensivamente. Las producciones mayores se obtuvieron a distancia de 20" x 3 1/2".

La productividad de la habichuela soya se afectó marcadamente con la época de siembra. Se lograron producciones de más de 40 "bushels" por acre en siembras realizadas desde mediados de febrero a mediados de septiembre. Las producciones más altas, que excedieron 60 "bushels" por acre, se obtuvieron en las siembras de mayo y junio y las más bajas (unos 20 "bushels" por acre) en las siembras de diciembre y enero. La época del año no afectó el tamaño de las habichuelas ni su contenido de aceite o de proteína. Estos datos señalan que pueden lograrse dos cosechas de habichuelas soyas al año en Puerto Rico con una producción combinada de más de 100 "bushels" (unas 6,000 libras) por acre.

La producción de habichuela soyá aumentó según se disminuyó la acidez mediante el encalamiento. La producción aumentó desde 1.6 "bushels" por acre a un pH de 4.3 con 20 por ciento de saturación de bases y 35 por ciento de saturación con aluminio a 34.8 "bushels" a pH 5.4 con 65 por ciento de saturación de bases y 5 por ciento de saturación con aluminio. El contenido de calcio y nitrógeno de las hojas de las habichuelas soya aumentó marcadamente con el encalamiento.

INTRODUCTION

There is little information on the effect of soil acidity, season of the year, and plant spacing on yields of soybeans growing under humid

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1/ This paper reports the results of research conducted cooperatively between the Soil and Water Conservation Research Division, Agricultural Research Service, USDA, and the Agricultural Experiment Station, College of Agricultural Sciences, Mayaguez Campus, University of Puerto Rico, Río Piedras, P. R.

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tropical conditions in Puerto Rico. Rodríguez[3] found that soybeans planted in spring, summer, or winter produced very low yields. Gaskins[4] found that the Hill and Hardee varieties producing 35 and 33 bushels per acre, respectively, outyielded the Clark, Improved Pelican, and F-64-1928 varieties in a June planting. When planted in July, however, these varieties produced only about 15 bushels per acre.

This paper summarizes the results of studies on the effect of planting date and plant spacing and soil acidity on yields of intensively managed soybeans of the Hardee variety under humid tropical conditions.

MATERIALS AND METHODS

The experiments were carried out at the Corozal Substation of the Agricultural Experiment Station, College of Agricultural Sciences, Mayaguez Campus, University of Puerto Rico. This Substation is located at an elevation of about 700 feet with temperatures ranging from 64°F. to 89°F. The soil is deep, red Corozal clay (Ultisol) with a pH of about 5.0, and an exchange capacity of 18 meq. of exchangeable bases per 100 grams of soil.

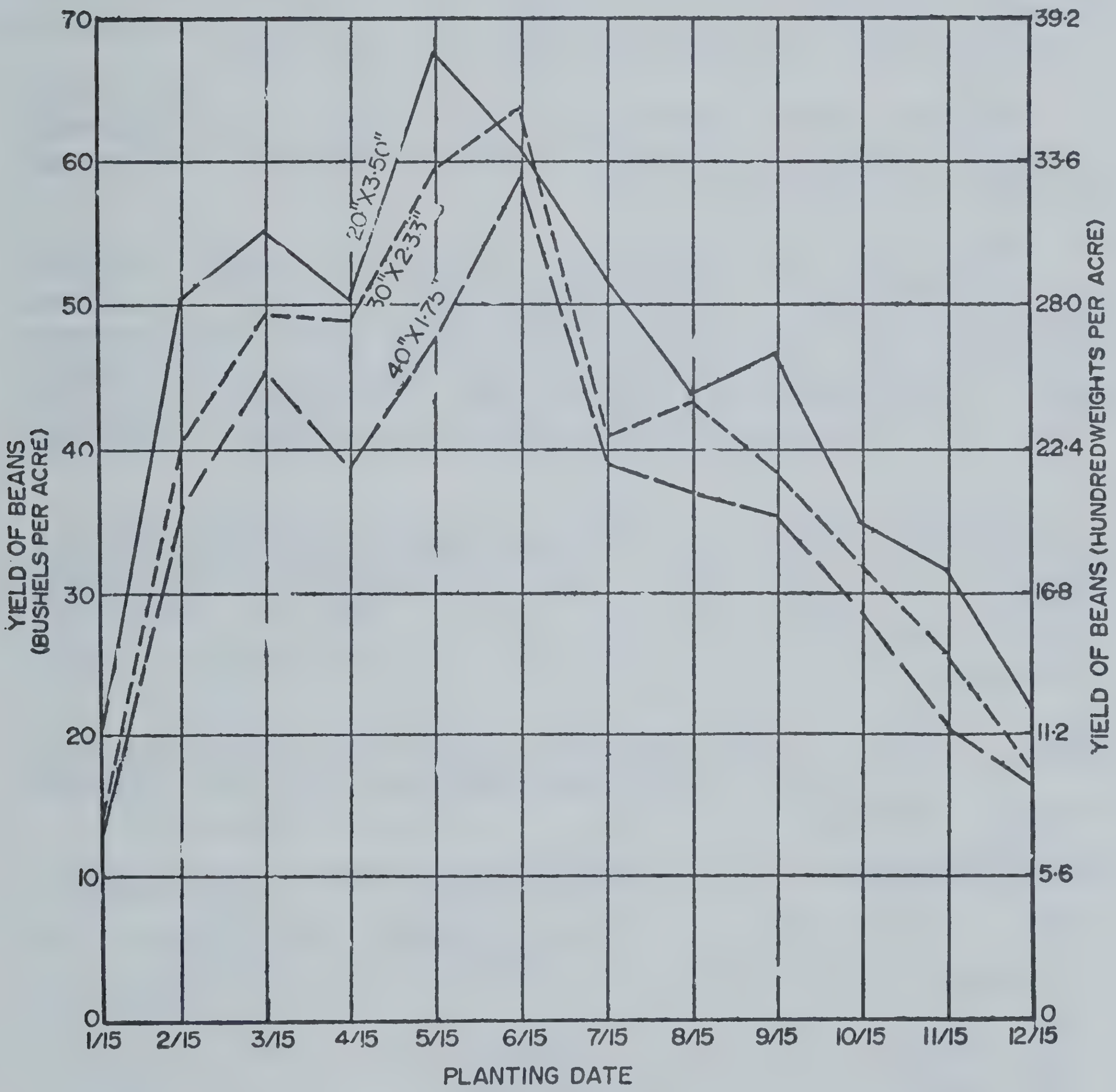
Plantings were made monthly throughout a year with 20-inch X 3 1/2-inch, 30-inch X 2 1/3-inch, and 40-inch X 1 3/4-inch spacings (90,000 plants per acre). An additional planting was made on November 17, 1971 to determine the effect on yields of populations ranging from 80,000 to 650,000 plants per acre, during the winter when plant growth is limited and yields are usually low.

Treatments were replicated four times using 12-feet X 12-feet plots. The soil was limed to pH 6.0 and received 100 pounds of P (as triple superphosphate), 100 pounds of K (as potassium sulfate), and 50 pounds of Mg (as magnesium sulfate) per acre in one banded application 2 weeks after planting. The seed was inoculated and planted in furrows. The plots were sprayed weekly with Diazinon and Dithane 45 to control insects and diseases. The soybeans were harvested and dried to 14 percent moisture. Similar practices were followed in the experiment on the effect of soil acidity except that the soil was limed to 4 levels of acidity. Also, spacing was standard 3" x 18".

3/ Rodríguez, Pastor J., Soybean Trials in Puerto Rico, Agr. Exp. Sta., Univ. P.R. Bull. 75, 1947.

4/ Annual Report of the Federal Experiment Station at Mayaguez, P.R.

Figure 1. --The effect of season and spacing on yields of Soybeans at Corozal.



RESULTS AND DISCUSSION

Highest yields were obtained with the closest row spacing combined with widest plant spacing (20 inches X 3 1/2 inches) to maintain a population of approximately 90,000 plants per acre (Fig. 1).

Soybean yields were markedly affected by season of the year (Fig. 1). With a 20-inch X 3 1/2-inch spacing, yields exceeding 40 bushels per acre were obtained in mid-February to mid-September plantings. Highest yields, exceeding 60 bushels per acre, were obtained from May and June plantings and lowest yields, about 20 bushels per acre, from December and January plantings.

Only 70 to 90 days were required to produce a crop with September to January plantings, compared to 110 to 130 days for planting made during the remainder of the year.

Table 1 shows that yields from a winter crop (planted November 17) were increased from 33.2 bushels with the usual population of about 80,000 plants per acre to 53.1 bushels with 220,000 plants per acre. These high yields were produced during a growing period of only 97 days. It is evident that the smaller plants produced during this season of the year can be planted close together without lodging or markedly reducing yields of the individual plants.

Protein content of the soybeans, which ranged from 40 to 44 percent, and oil content, which ranged from 20 to 23 percent, were not affected by spacing or season of the year. Bean size, which ranged from 20 to 24 g/100 beans, also was not affected by spacing or season of the year.

Table 1.--Effect of plant population on yields of soybeans during the winter of 1971-72 (planted November 17, harvested February 24)

Average spacings	Plants per acre	Yields
Inches		Bushels/acre
18 x 4.3	80,000	33.2
6.4 x 6.4	150,000	42.4
5.2 x 5.2	220,000	53.1
4.2 x 4.2	350,000	54.6
3.5 x 3.5	500,000	56.8
3.1 x 3.1	650,000	58.8

The data in this paper show that two crops of soybeans, with combined yields of over 100 bushels (about 6,000 pounds) per acre, can be produced yearly in Puerto Rico. Also, it is theoretically possible to produce three crops with a total yield of 160 bushels per acre yearly as shown below.

Planting date	Harvested in--	Yield
Month	Days	Bushels per acre
November 5/	95	53
March	115	53
July	125	54
Total	335	160

Table 2 shows that soybeans yields increased markedly with decreasing soil acidity up to the highest lime rate tested. Yields ranged from 1.6 bushels per acre at pH 4.3 with 20% base saturation and 35% aluminum saturation of the exchange complex to 34.8 bushels at pH 5.4 with 65% base saturation and 5% aluminum saturation.

This table also shows that calcium and nitrogen content of the leaves increased sharply with increasing lime rates but that the latter had no effect on phosphorus content.

Table 2.--Effect of soil acidity on yields of soybeans growing in a Corozal clay.

Soil acidity factors			Yields of soybean (bu/acre)	Foliar composition (percent)		
pH	Base saturation (percent)	Al saturation (percent)		N	Ca	P
4.3	20	35	1.6	2.27	.81	.25
4.6	35	25	9.4	2.78	1.11	.23
4.8	50	15	15.8	3.17	1.33	.25
5.4	65	5	34.8	4.26	1.65	.26

5/ 220,000 plants per acre.

INTERFERENCE OF PLANT AND SOIL FACTORS IN SOYBEAN NODULATION IN TROPICAL AND SUBTROPICAL REGIONS

Johanna Dobereiner 1/

La inoculación de soyas con la bacteria Rhizobium en los suelos ácidos del trópico es indispensable y no hay duda de su ventaja sobre los abonos nitrogenados minerales. Estos abonos son costosos y hay una gran pérdida por percolación debido a las lluvias. Trabajos de investigación recientes indican que además de la selección de diferentes tipos de Rhizobium y su producción, el genotipo de la planta también es muy importante en lo que concierne a nodulación de las plantas. Esta condición se ha observado en Brazil en cruces de cultivo IAC-2 para obtener cultivares para latitudes más bajas adaptadas para días cortos. Las progenies de estos cruces algunas modulan y otras no, indicando que se debe de seleccionar para los tipos o segregantes que modulan. Otro factor que se debe de considerar es el efecto de la interacción del abono y factores ambientales con el genotipo de la planta.

Inoculation of soybeans in acid tropical soils is indispensable and there is little doubt as to its advantage over mineral nitrogen ferlizers which are not only much too expensive to be used in such extensive areas, they are also unreliable due to fast percolation with the heavy rains and extreme low base exchange capacity of such soils. In Brazil soybeans are expanding rapidly from the subtropical South to the Central Highlands (Cerrados) and the insignificant production of 300 000 t in 1960 jumped to more than 4 million metric tons in 1973 when this crop became the most important export product after coffee (Table 1). Mineral nitrogen fertilizers are hardly ever used in Brazil for soybeans and inoculation is required by the banking institutions in order to give credits. There are six inoculant industries and all required inoculants are produced locally (Table 2). Systematic strain selection programs are routine procedures in four Government Institutions which recommend strains to the industries.

Recent developments in soybean inoculation research however, indicate that Rhizobium strain selection and inoculant production are

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Table 1

World Soybean production in millions of metric tons

Country	1968[a]	1971	1972	1973 (est.)
U.S.A.	30.0	33.0	33.8	
China	10.7	9.5	11.0	
Brazil	0.6	2.8	3.0	4.4
Others	2.5	1.9	2.2	

[a] FAO annuary

Table 2

Soybean Inoculant Production in Brazil, in 1973

Trade Name	Nº of Units Produced (for 50 kg seeds each)
IBPT	130 000
Turfal	1 200 000
Nitral	900 000
Leivas Leite	500 000
Beacon	300 000
Bio-Soja	100 000
	3 130 000

(Araújo 1974, personal communication)

not the only problems to be solved and are seldom limiting factors. Increasing importance is being attributed to plant genotype effects (Johnson & Means, 1960; Caldwell, 1966; Caldwell & Vest, 1968; Vest, 1970). In Brazil, in repeated National soybean cultivar trials, a general tendency of "easy" or "hard" nodulation has been observed for many years which seemed independent of the inoculant used. It seemed, however, difficult to define this difference as it varied with environmental conditions and soils. But part of the problem cultivars have now been identified, as non-nodulating with the Australian strain CB 1809 (Table 3). A clear-cut distinction between non-nodulating (less than 4 nodules) and well-nodulating (more than 30 nodules) plants was possible and few plants (mainly from cultivar L 652-8) showed intermediate, that is poor nodulation. The aspect of the plants which were either dark green and healthy or yellow and small, confirmed this. The cultivars which do not nodulate with CB-1809 are all related to IAC-2 (formerly I-2006). A few well-nodulated, dark green plants were found among them indicating segregation. To test this, 100 seeds each of IAC-2, Mineira and 70-450 were planted and 3, 8 and 83% well-nodulated segregants were found, respectively. Any doubful plants were

Table 3

Nodule numbers on easy nodulating and hard nodulating soybean cultivars, inoculated with CB-1809, in two soils (8 plants of each cultivar were examined) (Dobereiner & Arruda 1974, unpublished)

Cultivar	Nº of plants with less than 4 nodules		Nº of plants with more than 30 nodules	
IAC-2	Soil I	Soil II	Soil I	Soil II
IAC-2	8	7	0	1
70-558	7	8	1	0
70-559	8	8	0	0
IAC- 7025	0	0	8	8
IAC- 7052	0	0	8	8
IAC- 20223	0	0	8	8
IAC 789	0	0	8	8
Vicoja	0	0	8	8
Sta. Rosa	0	0	8	8
IAC-70-450	4	1	4	6
Mineira	4	6	4	1
F61 29 26	3	0	4	8
I-652-8	0	0	5	3

eliminated after identification which in most cases was clear cut by leaf color and plant size; all plants were fertilized with mineral nitrogen and seeds harvested from individual plants. All seeds from nodulating plants produced 100% well-nodulated plants while seeds of non-nodulating plants either produced only non-nodulating plants or segregants (Table 4). The nodulating segregants were multiplied in four further generations, all plants continuing well nodulated. This indicates a dominant non-nod factor similar to Rj-2 and Rj-3 (Caldwell, 1966 ; Vest, 1970).

Table 4

Segregation of non-nod and nod characters in three soybean cultivars inoculated with CB 1809 (Dobereiner & Arruda 1974, unpublished)

	Nº of plants used (20 seeds each)	Nº of nod plants (total)	Nº of plants segregating	% segreg. among segregating pl.
IAC-2 (L-2006)				
-nodulated	9	4	3	6.6
Nodulated	2	40	0	0
Mineira				
-nodulated	8	7	2	17.5
Nodulated	3	60	0	0
IAC - 70.450				
-nodulated	8	17	3	28.3
Nodulated	3	60	0	0

The late flowering cultivar IAC-2 is being used extensively for breeding work directed towards shorter day requirements in order to obtain cultivars for lower latitudes as those in the Central Highlands in Brazil which present a tremendous potential for soybean growth in large scale. Seeds from IAC-2 from different origins (Km 47, Goiania, Brasilia) showed the same problem. Furthermore, from eight crosses of IAC-2 with Hardee, which are being selected for the region of Brasilia (Duque 1973 personn. comm.), none nodulated with CB-1809 neither did they seem to segregate. From two crosses, Hardee x Pelican, one nodulated, the other not. The cultivar Sta. Rosa, which is the most common cultivar in Sao Paulo State, in these experiments nodulated well with CB-1809.

Poor or no nodulation of IAC-2 was also observed with 17 other strains used commonly in inoculants, while only three strains from our collection (two Japanese strains 965 and 846 which are serologically related and CB 1795) and two strains from Porto Alegre (566 and 532) according to Araujo et al. (1970) are effective. Experiments are being presently conducted to compare these findings with those of the Beltsville group, where the specific host-strain interaction with only two serogroups (C-1 and 33) seemed of little economic importance (Caldwell, 1966; Sloger, 1973 person. com.). Strain CB 1809 was tested against the C-1 serogroup and several other Beltsville strains (but not strain 33) showing no relationship, but our strain R 54a, which also does not nodulate IAC-2, cross reacted with strain 38 from Beltsville, a strain which does not nodulate the soybean genotype D49 772 (Caldwell & Hartwig, 1970). Studies on the nodulation of IAC-2 with the Beltsville strains, and mainly the nodulation of the nodulating IAC-2 segregants with the 17 strains which do not nodulate the IAC-2 parent, should be revealing. Specific strain selection parting from the few nodules on the non-nodulated plants was successful, two out of 15 isolates being better than the two Japanese strains, in pot experiments. But a much more elegant and useful solution of the whole problem seems the multiplication of the nodulating segregants.

Fertilizer and environmental factors can interact with plant genotype (Dobereiner & Arruda 1967) and are probably as important to maximize N_2 input. Numerous experiments show that phosphorus and lime are the major limiting factors in most Brazilian soils (Freitas et al., 1971, 1972, Santos et al., 1972) and the assessment of economic levels is basic for any more sophisticated study (Lobato et al., 1967). Molybdenum, Zinc, boron and manganese deficiencies have not been shown individually for soybeans but are to be taken in consideration, as forage legumes dependent on symbiotic nitrogen fixation showed two (De-Polli & Dobereiner, 1973; De-Polli & Suhet, 1974) to ten fold (Franca & Carvalho, 1970) yield increases with these elements in red yellow podzolic soils and latosoils respectively. Fritted trace elements (F.T.E.) increase nodule and plant weight of soybeans more than five fold in two Cerrado latosoils (Dobereiner, 1972 unpublished). Aluminium and manganese toxicity limit nodulation and nitrogen fixation before plant growth (Dobereiner, 1968; Coutinho et al., 1970, Franco & Dobereiner, 1971) and are very wide spread in Brazil (Goodland, 1971; Mendes, 1967; Coutinho, 1970).

Excessive soil temperatures affect nitrogen fixation and nodulation 33°C being given generally as limit, and strains isolated from warmer regions seem more tolerant than strains from temperate regions (Galetti et al., 1971; Day et al., 1972). Recent findings show (Hardy et al., 1973) that the N_2 input barrier can be overcome by CO_2 fertilization, which increased the N_2 contribution from 25 to 83%. Shading exper-

Fig. 2. Differential effectiveness of Rhizobium strains, at three temperatures (705 from USA, CB1809 from Australia, SM1b Brazil) after Dart et al. 1973.

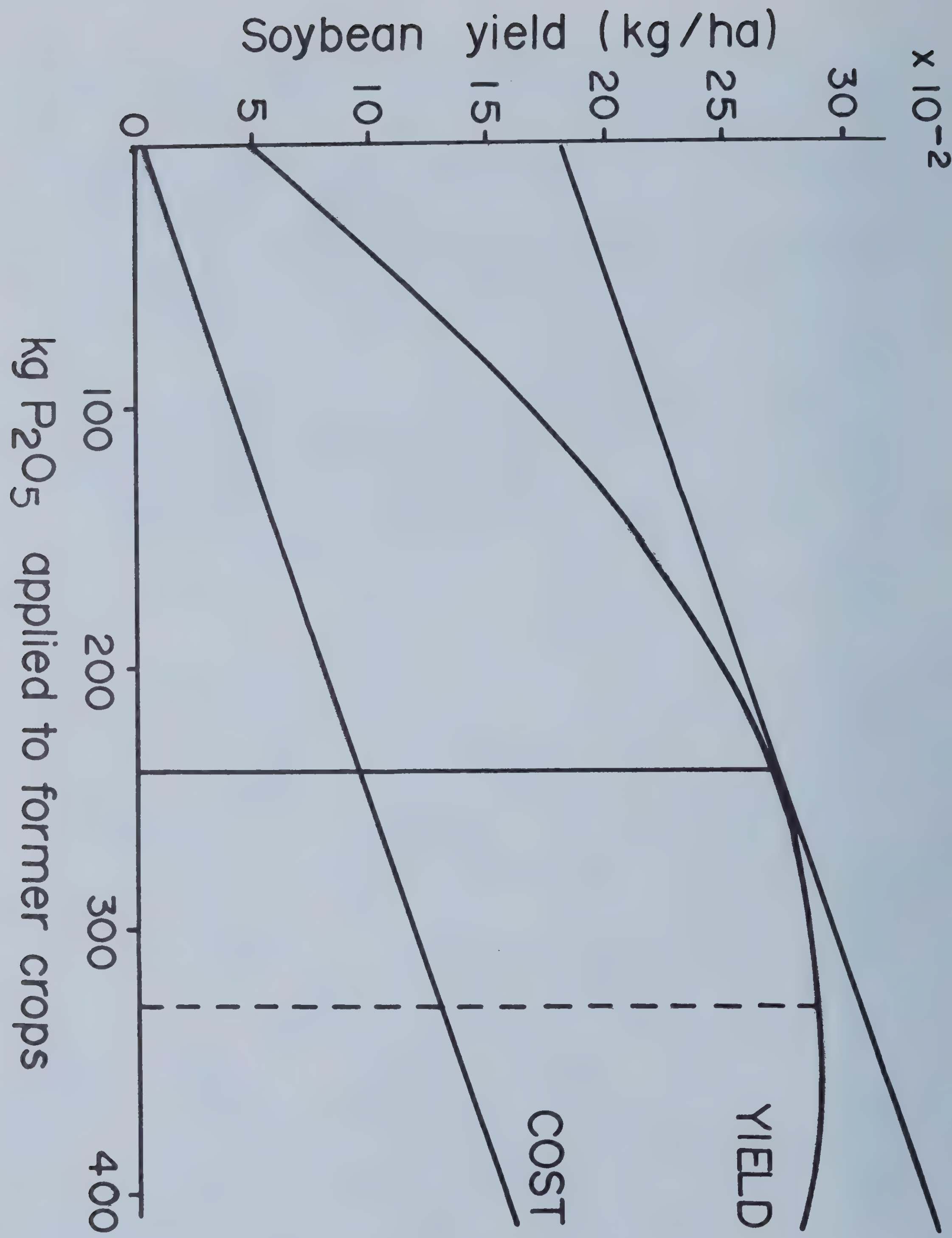

Figure 2. Effect of phosphorus on maximal and maximal economic yields of soybeans in Cerrado soil (Lobato, 1967)

iments indicate also light intensity as limiting factor for nodulation and nitrogen fixation (Sampaio & Dobereiner, 1968; Rocha et al., 1970). This indicates that photosynthesis is in fact the ultimate limiting factor of N_2-fixation in soybeans, another argument for extending this crop to the constantly sunny regions of the Brazilian Central Highlands.

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WEED CONTROL IN SOYABEANS

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El rendimiento de habichuelas soyas en el trópico se puede reducir hasta un cincuenta por ciento cuando no se controlan los yerbajos, según la evidencia presentada en este trabajo. Muchos de los yerbajos tropicales son extremadamente rápidos en su crecimiento y si no se controlan, las soyas estarán en desventaja para su crecimiento y desarrollo normal. Se recomienda una rotación de cultivos para reducir a un mínimo el problema de los yerbajos. Se menciona la flora de yerbajos más comunes en Trinidad y Jamaica, los cuales son bastante típicos del trópico. Se discuten los métodos de control con yerbicidas de pre y post-germinación y los métodos o prácticas de cultivo.

A majority of published material on weed control in soyabeans is, not surprisingly, North American in origin. Although soyabeans have long been important in tropical and subtropical South East Asia, the crop is grown there mainly as a food crop, largely by traditional subsistence farming techniques. Interest in the crop in the Caribbean region arises mainly from the need to save foreign exchange, allied to potential increases in the demand for soyabeans, both to increase the output of livestock products and for processing into foodstuffs. Plans for local production generally envisage "field production" of dry seed with a fairly high degree of mechanisation, rather than small-farmer production, though the latter may have a role to play in producing "vegetable type" soyabeans. Work in U.W.I. has so far concentrated mainly on "field production".

Although there is, relatively, a dearth of published information on weed control in soyabeans in the tropics, work has been reported from Trinidad (Radley, 1968; Seeyave & Thompson, 1969; Donelan, 1972; Hammerton, 1972a), Jamaica (Hammerton, 1971, 1972b) India (Bhan, Madrid, 1968) and Nigeria (Moody, 1972). No doubt work is in progress in many other territories, particularly in view of recent shortages on the world market.

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I propose discussing this topic under the following main heads:-

1. Effects of weeds on soyabeans

2. Weed Floras (mainly those reported from plantings in Jamaica and Trinidad).

3. Weed Control

4. Conclusions

This is not a comprehensive review and much of it is based on work done by colleagues, past and present, and by myself in Jamaica and Trinidad. Hopefully, it will stimulate discussion and suggest future lines of research and development.

1. The Effects of Weeds

Tables 1 to 4 illustrate the effects of weeds on yields. In general, absence of weed control reduces yields by about 50%, though I suspect that losses could go much higher given certain weed floras and /or environmental checks to soyabean growth.

Delay in weeding —by hand or mechanical methods (and possibly by post-em herbicides)-- clearly reduces yields. Similarly, maintenance of good control for too short a period of time also reduces yields. Thus in Table 1, a delay of only 3 weeks (from planting) in starting to control weeds significantly reduced yields, while maintaining weed-free conditions for 6 weeks was insufficient to give a yield comparable to the clean-weeded control. The data of Bhan et al (1970) in Table 4, however, show that a 30-day delay did not reduce yields, relative to the clean weeded control; but note that weeding at 15 days was apparently superior to the clean control. Their data also suggest that maintaining weed-free conditions for 30 days was adequate.

Of the components of yield, plant number can be reduced by weed competition and delayed weeding. Pod number per plant is normally severely reduced by weed competiton: the data of Donelan (1972) in Table 2 ilustrates this, and North American reports agree (e.g. Moolani, Knake & Slife, 1960). On seed number per pod there is no unanimity. Knake & Slife (1962) in Illinois reported no effect of weed competition on this component, but Donelan (1972) (Table 3) recorded a reduction with weed competition, and Dasasian (1971), in a review, also suggests that weed competition may reduce seed number per pod. This component may be very susceptible to water supply at pod-setting and -filling, so that, as Staniforth (1959) points out, the outcome of competition may depend on soil moisture supply. Seed size is usually

unaffected by competition, according to Donelan (1972) but Hammerton (1972 a) (Table 1) found a reduction in seed size (1000-seed weight) with delayed weeding and with no weeding and also a reduction in the seed-weight of filled seeds with these treatments.

The duration or level of weed control may interact with plant population and row spacing. The data of Table 2 show that the loss of yield was greater with wide than with narrow rows. Donelan (1972) also found evidence that certain spatial arrangements reduced weed growth, and the impact of weeds on yield. Crop nutrition, nodulation (and therefore inoculation) may also influence the outcome of competition.

To sum up: good weed control during early growth is essential for high yields. Relatively weed-free condition may need to be maintained for up to half the duration of the crop. This suggests pre-plant and/or pre-em herbicides, probably reinforced by mechanical cultivation and/or post-em herbicides.

2. The Weed Floras

Any crop species introduced to a new area, particularly if, like soyabeans, it is relatively inefficient photosynthetically, is likely to be at a considerable disadvantage in competition with the local, adapted weed flora. Many tropical weeds are extremely rapid in growth, and readily swamp a soyabean planting, particularly if a check to crop growth occurs. The weed, following a resting period during which weed growth proceeds usually unchecked, allows production of propagules and seeds and exacerbates weed problems. Use of the rotavator may assist the spread of vegetative propagules, and seed-bearing plant parts, also exacerbating weed problems. Soyabeans should therefore be grown as part of a rotation in which crops and cultivations are selected to minimize progressively the weed problems, particularly in the "sensitive" crops--such as soyabeans.

Moody (1972) in Nigeria has produced a species list of weeds in soyabeans that includes 23 families and 68 species and aggregates. His major weeds include a Commelina spp., a sedge (Mariscus alternifolius), the grasses Brachiaria deflexa and Setaria barbata and a legume (Indigofera hirsuta). Less comprehensive lists have been compiled for crops in Trinidad by Donelan (1972) and in Jamaica by Hammerton (1971, 1972b and unpublished). Adams, Kasasian & Seeyave (1970) have published an illustrated book describing the common weeds of the West Indies.

In Trinidad, Brachiaria extensa, Paspalum fasciculatum and

Panicum muticum were common. All are ranked tall, growing grass weeds, vegetatively propagated and difficult to control by herbicides or mechanical means. Digitaria spp., Eleusine indica, Echinochloa colonum, Rottboellia exaltata and Cynodon dactylon were also recorded among the grass weeds. Many of these are quick growing ephemerals that can germinate and establish between cultivations. They are not always adequately controlled by herbicides and C. dactylon is particularly difficult. Among the broad-leaved weeds Euphorbia spp., Phyllanthus amarus and Cleome ciliata were common in two experiments. These are generally low growing, but can occur at very high densities. Amaranthus dubius and Alternathera ficoidea were also present in one experiment. These are tall growing and readily shade soyabeans. The latter can root at nodes, but both are tap-rooted and may be difficult to control by cultivation once established. Cyperus rotundus and Fimbristylis miliacea (another sedge) were also present: both are difficult to control, particularly the former.

In Jamaica, C. rotundus, E. colonum and Sorghum vertilliflorum have proved serious weeds. Commelina elegans, Portulaca oleracea Euphorbia spp., Amaranthus spp., Boerhavia diffusa, Lagascea mollis and Parthenium hysteriphorus have been the major broadleaved weeds. The latter two species are extremely troublesome and rapidly dominate the crop if unchecked. They also appear tolerant of many herbicides at rates safe to soyabeans. P. hysterophorus is also resistant to paraquat, which might be used as an inter-row directed spray. P. oleracea and C. eleganis also appear to tolerate many herbicides and to re-establish readily after mechanical disturbance. Other weeds recorded include C. dactylon, Cenchrus echinatus, Ipomoea spp., Bidens pilosa, Kallstroemia maxima, Tribulus cistoides, Celome viscosa and C. ciliata, Sida acuta and Macroptilium lathyroides. Some of these appear difficult to control with herbicides, but quantitative data on this aspect are lacking. For control of many of these weeds, good mechanical methods and/or safe post-em treatments are needed. Weeds within the crop row are particularly troublesome and amenable only to overall post-em treatments or hand weeding.

Weedfloras will vary between territories and between sites within territories. The above account can therefore only serve as a guide to some of the commoner weeds of arable land in the Caribbean and highlight some of the problems that have been encountered in Trinidad and Jamaica.

3. Weed Control

A. Herbicides

For simplicity of presentation, herbicides are discussed individ-

ually, based mainly on data obtained in Jamaica (Hammerton, 1971, 1972b and unpublished) but amplified, where relevant, with information from elsewhere.

Preplant Incorporated Treatments

(i) vernolate (VERNAM) at 2-3kg/ha has controlled *C. rotundus* and other weeds (principally grasses) for a few weeks. It must be immediately incorporated due to its volatility.

(ii) EPTC (EPTAM) at 2-3 kg/ha is more effective as a weed-killer, but can damage soyabean emergence.

(iii) trifluralin (TREFLAN) at 0.75-1.0 kg/ha has not given satisfactory weed control: at higher rates it has damaged stands (Moody, 1972) and even at low rates reduces root growth. Damage appears greater with frequent watering (Feeny & Cole, 1966) and is increased by incorporation below the planting depth (Oliver & Frans, 1968). Trifluralin and the related nitralin (and possibly others of the aniline group) can cause stem brittleness and lodging (Shepherd *et al*, 1968).

(iv) nitralin (PLANAVIN) is generally less selective than trifluralin and has given variable results.

(v) A-820 (Amchem's AMEX?), at 3-4 kg/ha has proved safer and more effective than trifluralin, to which it is chemically related.

(vi) alachlor (LASSO) has proved very good at 2kg/ha but is probably better used pre-em.

(vii) H-722 (RH 26715) gave good weed control without crop damage at 1.5 but not at 3.0 kg/ha. Its current status is unknown.

Pre-emergence Treatments

(i) cholorbromuron (MALORAN) at 2 kg/ha has given good control without crop damage, but Moody (1972) found loss of stand with this compound.

(ii) alachlor (LASSO) at 2 kg/ha has consistently given good control of a wide spectrum of weeds without crop damage. Higher rates could probably be used safely to increase weed kill. The related propachlor (RAMROD) has proved less effective, but is also safe.

(iii) chloramben (AMIBEN), although widely used in the U.S.A., has proved variable in weed control in Jamaica and Trinidad (Donelan, 1972). Much depends on the weed flora, but this compound is un-

satisfactory on light soils and where heavy rain or watering can cause leaching. Moody (1972) found it gave excellent weed control, however, when combined with alachlor.

(iv) metribuzin (SENCOR), on limited evidence, appears to have a low selectivity index: 0.6 kg/ha appeared safe but not 0.75. Incorporation greatly increased crop damage. Weed control was excellent at these rates.

(v) oxadiazon (RONSTAR) at 2 kg/ha appears promising and deserves further evaluation.

(vi) dinoseb has a low oral LD50 and can be very damaging in soyabeans. The combination with naptalam (DYANAP) has given excellent weed control but severe crop damage.

(vii) naptalam with chlorpropham (SOLO) has also given severe crop damage (at 4.5 kg total ai/ha). Chlorpropham alone deserves testing in soyabeans, though Moody's (1972) data do not rate it highly alone or in combination with linuron.

(viii) linuron (LOROX) has been severely damaging at 1 and 2 kg/ha in Jamaica. At even lower rates plus wetter it may be useful, and deserves testing, as a directed post-em spray (e.g., Johnson, 1971). This is also true of prometryne and chloroxuron, both of which have performed indifferently as pre-em treatments.

(ix) metobromuron (PATORAN) appears similar to chlorobromuron in safety and weed control. Chlorthal (DACTHAL) (at 4.5 kg/ha) has given good weed control but appears unreliable in it effects. This is also the experience with diphenamid (DYMID). Mixtures of diphenamid and chlorthal appear safe to soyabeans and several other crops however, and together with diphenamid/chloramben mixtures have been recommended by Kasasian & Seeyave (1968). Their effectiveness as weed-killers probably depends very much on the weed flora and possibly on rainfall incidence.

(x) fluorodifen (PREFORAN) at 2-2.5 kg/ha has proved a good weedkiller but tends to cause crop damage.

(xi) In preliminary trials, benthiocarb (SATURN), MBR 8251 (DESTUN), 2810 RP and carbetamide (LEGURAME) all appear worth further testing. AC 92390, AC 92553 and U 27267 also merit further testing, based on experience in Jamaica, both as pre-em and ppi treatments.

Post-emergence Treatments

(i) chloroxuron (TENORAN) at 1-2 kg/ha plus wetter can be used when soyabeans are in the unifoliate stage. Some scorch may result, and limited experience suggests that some weeds are unharmed.

(ii) dinoseb and linuron have been mentioned above. Both can be applied post-em, but may cause severe scorch.

(iii) 2, 4-DB has a limited weed spectrum and can cause crop damage.

(iv) paraquat carefully directed as an inter-row spray was tested by Donelan (1972). If well timed and carefully applied, weed regrowth is checked by crop competition and crop damage is minimal.

All post-em treatments appear potentially dangerous as overall sprays, and as directed sprays fail to control weeds within the row. They may be useful to supplement ppi and/or pre-em treatments, however.

B. Cultural Methods

These continue to be widely used by U. S. growers to supplement herbicidal control. In many tropical countries there appears to be little tradition of intensive use of inter-row cultivations.

Rolling cultivators can give excellent control of weeds if used when weeds are just emerging, and when the soil is lightly crusted. "Flextine" and spring tine cultivators are also good; again they must be used early and when soil conditions are dryish. "Sweep" hoes and steerage hoes can also be used. All these implements require careful operation to perform well. Flaming is of doubtful value as a method of weed control in the tropics. Tractor-mounted multi-row shielded sprayers for inter-row treatment are expensive and require careful maintenance, adjustment and operation, but may be useful for supplementary weeding if hoes cannot be used due to unfavourable soil conditions.

4. Conclusions

Weed control should be regarded as an integral part of crop production, rather than as a troublesome addition. To this end much greater attention needs to be given to crop rotation, particularly where relatively large-scale mechanical production of food (and other short-term) crops is considered. Rotations should include planned use of herbicides residue damage. Soyabeans are particularly sensitve to

triazine residues: heavy applications of atrazine, for example, should not be made to a preceding corn crop. Rotations must take account of photoperiodism, incidence of rainfall and seasonal changes in pest and disease incidence. Suitable crops for combination with soyabeans include corn, dry beans and several vegetables.

Soyabeans are not a suitable crop for weedy land. Corn should be used as the pioneer crop on such land, since it offers many opportunities for weed control (e.g, ppi butylate or EPTC plus safening agent; pre-em atrazine and/or alachlor and others; post-em 2, 4-D, atrazine-in-oil, etc.) and inter-row cultivation.

In many situations, combinations of herbicide treatments (e.g., ppi vernolate or A-820 plus pre-em alachlor) and/or cultural methods may be needed. The necessary equipment must be assembled before the final land preparation, since timeliness is essential.

The interaction of row spacing and weed control is worth exploiting but poses a dilemma. Close rows can act synergistically with herbicides, but preclude inter-row cultivations. On weedy land, wider rows, to allow inter-row cultivation, are safer than closer rows and reliance on herbicides. On relatively clean land, however, close rows plus herbicides with no inter-row cultivation is possible and may give maximum yields. The apparent lack of safe post-em herbicide treatments means that weeds within the crop row can be countered only by pre-em treatments allied to close planting within the row to exert a smothering effect.

Where irrigation is available, or is necessary for soyabean production, attention to irrigation method in relation to herbicides will be needed. Overhead systems are probably too expensive; if furrow irrigation is used, leaching of herbicides from furrow bottoms, with subsequent weed growth, may pose problems, and redistribution of herbicides in the ridges may result in toxicity to the crop. Even without furrow irrigation, wheelways may be needed to enable crop protection spraying to be continued after the canopy has almost closed. These wheelways will need special attention to control weeds.

Table 1. Effect of time of weeding on yield of soyabeans and on mean 1000-seed weight, % filled seed and 1000-seed weight of filled seeds. (Source: Hammerton, 1972a)

	Weedy	Weed-free until 3 weeks	Weed-free until 6 weeks	Weed-free from 3 weeks	Weed-free from 6 weeks	Weed-free
Yield (kg/ha) _ 37.2	956d	1498c	1694b	1774b	1373c	1997a
Mean 1000 seed weight (g) _ 1.8	104c	148b	158a	157a	147bc	161a
% filled seeds	62b	79a	79a	84a	81a	84a
1000 seed weight of filled seeds (g) _ 2.3	160bc	163abc	167ab	164abc	154cd	170a

Table 2. Effect of interaction of time of weeding and row spacing on yield

	Weedy	Weed-free until 3 weeks	Weed-free until 6 weeks	Weed-free from 3 weeks	Weed-free from 6 weeks	Weed-free
Close rows (30.5 cm)	1254e	1642e	1803bc	1969ab	1524d	2127a
Wide rows (61.0 cm)	658f	1354de	1585ed	1578cd	1222e	1867b

Note: Plant population was significantly greater with close rows, though the intended populations were identical.

Table 3. Effect of weed control treatments on yield of soyabeans and on pods per plant, seeds per pod and mean 1000-seed weight in two experiments, A. and B. (Source: Donelan, 1973)

	Clean Weeded	Paraquat inter-row	Chloramben -diphenamid pre-em	Weedy
Yield (kg/ha) - 61 (A)	1976a	1947a	1979a	1257b
Yield (kg/ha) - 72 (A)	1954a	1708b	1648b	992c
Pods per plant - 0.9 (B)	20.3a	19.0a	18.9a	12.2b
Seeds per pod - 0.03 (B)	2.06a	2.06a	1.91b	1.89b
Mean 1000-seed weight (g) - 3.0 (B)	183a	184a	180a	164b

Table 4. Effect of time of weeding on yields of soyabeans. (Source: Bhan, Singh & Maurya, (1970)). Note lack of statistical tests of significance.

	Weed-free	Weeded at 15 days	30 days	45 days	60 days	Harvest
Yield (kg/ha)	3089	3506	3020	2796	2743	1615

	Weed free until 15 days	30 days	45 days	60 days	Harvest
Yield (kg/ha)	2606	3367	3448	3262	3395

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VIRUSES AFFECTING SOYBEANS IN PUERTO RICO

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La soja no se siembra comercialmente en Puerto Rico a pesar de que se pueden obtener magníficos rendimientos mediante el empleo de prácticas tecnológicas modernas. Hasta ahora poco se conocía sobre los virus fitopatogénicos que afectan la antedicha cosecha en Puerto Rico. Recientemente se observaron dos mosaicos en plantaciones experimentales localizadas en las Subestaciones de Fortuna, Lajas, Gurabo e Isabela. La incidencia de uno de los mosaicos, el enanismo (achaparramiento) amarillo, era elevada (más de 25% en algunas variedades) en la Subestación de Fortuna pero casi inapreciable (aproximadamente 1%) en Isabela, Gurabo y Lajas. El virus que causa el enanismo amarillo no pudo ser transmitido por medios mecánicos pero se verificó experimentalmente que era propagado por la mosca blanca *Bemisia tabaci* Genn. Los resultados de estudios sobre la transmisibilidad, sintomatología y gama de hospederas indican que el agente que causa el enanismo amarillo de la soja en Puerto Rico es idéntico al incitado por el virus rugáceo de *Rhynchosia minima* DC. El otro virus detectado en el campo causa un mosaico efímero en la soja y fue transmitido experimentalmente (por medios mecánicos) a plantas de la variedad Jupiter. Otras especies corrientes tales como pepinillo, tabaco, habichuela y caupi no desarrollaron síntomas al ser inoculadas artificialmente. Los agentes que causan los mosaicos de *Crotalaria* y *Vigna* son capaces, según comprobamos, de infectar la soja en Puerto Rico. Sin embargo no logramos aislar estos agentes de las plantaciones antes mencionadas.

Soybeans are not grown commercially in Puerto Rico although excellent production was obtained by Silva *et al.* (10) using advanced technological practices. They were able to obtain yields of more than 3,400 lbs. per acre using the variety Hardee and stated that two crops could be produced in one year for a combined yield of 6,000 lbs. per acre. Similar results were obtained by Fox and Del Valle (7). In his textbook of *Plant Virus Diseases*, Smith (11) lists under soybeans only one virus, soybean mosaic virus, which is transmitted by several species of aphids including *Myzus persicae* and *Macrosiphum pisi*. This virus is seed-borne and can be transmitted mechanically. It produces vein clearing, mottling, stunting and rugose symptoms. According to Conover (5), symptoms induced by soybean mosaic may be severe at 18.5°C and masked at 29.5°C. The host range of soybean

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mosaic virus is very restricted. It is systemic only in soybeans, but can be recovered from the inoculated primary leaves of certain garden bean varieties.

Heretofore little was known about viruses affecting soybeans under our conditions. Recently two mosaic diseases were detected on leading varieties under cultivation in experimental plots located at the Fortuna, Lajas, Gurabo and Isabela Substations. Incidence of one of the maladies, yellow stunt, was high (upwards of 25% in some varieties) in the Fortuna Substation but almost negligible (approximately 1%) in Isabela, Gurabo and Lajas. The causal agent of the yellow stunt mosaic could not be transmitted by mechanical means from diseased to healthy soybean plants but was found to be spread by the Sida race of the whitefly Bemisia tabaci Genn. Results of transmission, symptomatology and host range studies indicate that yellow stunt of soybeans is identical with the mosaic of Rhynchosia minima, a disease whose causal agent is spread also by the Sida race of the whitefly B. tabaci (1, 2, 3, 12). The causal agent of the mosaic of R. minima is known to cause important diseases of other valuable crops in Puerto Rico including, among others, pigeon peas, beans, okra and tobacco. The vector of the yellow stunt virus of soybeans occurs in Florida where it was found by Costa and Bennett (6) on species of Sida in 1952. Yellow stunt mosaic is a potentially dangerous tropical disease of soybeans.

The second local disease, a fading mosaic, was first observed in Isabela and reproduced by mechanical inoculation of the variety Jupiter. Test plants of this variety, inoculated in the greenhouse, developed vein clearing and ringspots followed by mild chlorotic mottling and oak-leaf pattern mosaic. Most of the affected plants recovered from symptoms. This was probably due to the high air temperatures prevailing at the time. Transmission studies with fading mosaic were conducted during the months of August, September and October. Cucumber, tobacco, bean, cowpea and other plant species failed to develop symptoms of mosaic after inoculation with expressed sap.

The Puerto Rican cowpea mosaic virus (8) causes a systemic yellow mottle of soybeans. However, it has not been isolated from field grown soybean plants. This virus is beetle transmitted and seems to be closely related to the Arkansas cowpea mosaic studied by Shepherd (9).

Recently the writers isolated a virus from Crotalaria striata plants affected by a leaf distortion mosaic. The causal agent has a wide host range. Soybeans and beans develop a rather well defined mosaic a few days after inoculation. Attempts made to transmit the aforementioned virus via Aphis gossypii and A. craccivora to beans were not successful.

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BACTERIAL AND FUNGAL DISEASES OF SOYBEAN IN THE TROPIC AND SUBTROPICS

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Hay más de cincuenta enfermedades en habichuelas soyas que son causadas por hongos y cinco por bacterias, muchas de las cuales pueden ocasionar pérdidas considerables. Cinco de estas enfermedades son potencialmente de suma importancia económica en los trópicos y subtrópicos; éstas son: 1) el tizón causado por la bacteria Pseudomonas, 2) pudrición de la raíz, causada por el hongo Rhizoctonia, 3) el tizón del tallo y la vaina, causado por el hongo Diaporthe, 4) antracnosis, causada por el hongo Colletotrichum y 5) la soya, causada por el hongo Pakopsora. Se describen los efectos de los mismos y la parte de la planta que atacan.

There are over 50 fungal and five bacterial diseases of soybeans, many of which can cause serious losses. Some of the more important diseases caused by these bacteria and fungi are:

Bacterial (Foliage blights, seed and seedling diseases):

Common blight -- Pseudomonas glycinea
Wildfire -- Pseudomonas tabaci
Pustule -- Xanthomonas phaseoli

Fungal:

Root and stem decays:

Antracnose -- Colletotrichum truncatum
Charcoal rot -- Macrophomina phaseolina (Rhizoctonia bataticola)
Brown stem rot -- Cephalosporium gregatum
Rhizoctonia diseases -- Rhizoctonia solani
Pythium root rot -- Pythium spp.
Phytophtohora rot -- Phytophthora magasperma var. sojae
Pod and stem blight -- Diaporthe phaseolorum var. sojae
Stem canker -- Diaporthe phaseolorum var. caulivora

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Foliage spots and blights:

Rust -- Pakopsora pachyrhizi
Downy mildew -- Pakopsora pachyrhizi
Brown spot -- Septoria glycines
Frogeye spot -- Cercospora sojina
Phyllosticta leaf spot -- Phyllosticta sojicola

There are five diseases of soybeans that are potentially of great economic importance in the tropics and subtropics: common bacterial blight, Rhizoctonia root rot, pod and stem blight, anthracnose and rust.

The common bacterial blight organism lowers seed quality by reducing seed germination and emergence, and causes seedling diseases. The bacterium is omnipresent causing a leaf spot and under high humidity induces defoliation. Epidemics often follow heavy rains with strong winds.

Rhizoctonia root rot has caused severe losses in the soybean-growing areas of southern Brazil. Large areas or patches within a field show progressive dying of plants from about flowering to maturiry. It appears to be a root-rot complex involving at least two fungi, Rhizoctonia solani and Fusarium spp.

Diaporthe phaseolorum var. sojae (Phomopsis sojae) lowers seed quality by reducing seed germination and emergence, and causes seedling diseases. It also causes pod and stem blight, which weakens maturing plants, cause lodging and thus reduces yield. It is favored by high humidity.

Anthracnose is world wide in distribution and has caused serious losses in central India. It is favored by high humidity. It is seed-borne.

Soybean rust is found in the Far East, Russia, India, China and Australia. It is not known to occur in the Americas. All precautions must be taken not to introduce this fungus into the soybean areas of the Western Hemisphere. It causes a foliage blight, which can induce complete defoliation. Seed transmission is suggested.

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SOYBEAN NEMATODES

By James M. Epps[1]

Los nemátodos fitoparasíticos son un factor limitante en la producción de habas soyas en los Estados Unidos de Norte América. Los nemátodos noduladores y de quiste están causando pérdidas considerables en las áreas donde se cultivan las soyas. Encuestas realizadas indican que la pérdida de los agricultores por causa de los nemátodos es de alrededor de un diez por ciento de su producción total. Hay tres métodos que se utilizan para el control de los nemátodos: 1) Rotación de cosechas es un medio efectivo, pero en muchos casos está limitado por la falta de cultivos resistentes que encajen en el sistema de rotación. 2) El control químico es efectivo, pero muy costoso. 3) El uso de variedades resistentes está jugando un papel muy importante en el control de los nemátodos modulares y de quiste. Se están llevando a efecto programas de fitomejoramiento diseñados para utilizar el material del banco de material genético de soyas, para incorporar resistencia a los nemátodos y otras enfermedades. Este programa ha traído como resultado el desarrollo de variedades resistentes que puedan ser cultivadas en áreas donde no era económico la producción con las variedades susceptibles.

INTRODUCTION

Since production of soybeans has become a major crop in some parts of the United States, it has become increasingly evident that plant parasitic nematodes are one of the major limiting factors in the production of this crop. The acreage planted to soybeans on many farms is greater than the total planted to all other crops. This requires planting soybeans after soybeans and makes conditions favorable for build-up of nematode populations. When populations build up to high levels it is difficult to get yields that will return a profit to the producer. I will discuss some of the nematode parasites that are known to be injurious to soybeans.

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KINDS OF NEMATODES

More than twenty kinds of nematodes have been identified from soybeans, some of which are capable of inflicting heavy damage to this crop (3, 4, 9). Among the major nematodes attacking soybeans are: Soybean cyst (Heterodera glycines); root-knot (Meloidogyne spp.); lesion (Pratylenchus spp.) (6, 7); reniform (Rotylenchulus reniformis); lance (Hoplolaimus spp.); sting (Belonalaimus longicaudatus); spiral (Helicotylenchus spp.) and others. The soybean cyst and root-knot nematodes have received the greatest emphasis in research programs, and much valuable information is available on these and the other nematodes.

This information is being utilized by those workers engaged in solving nematode problems of soybeans. The application of the research is playing an important role in soybean production. None of the bud and stem nematodes have been reported on soybeans.

SYMPTOMS OF NEMATODE INJURY TO SOYBEAN

Some mechanical injury to plant tissue may result when plant nematodes move while feeding. Some of the internal parasites, like the lesion and lance nematodes cause greater mechanical injury than some of the external feeders like the stubby-root nematode. Considerable injury is due to the tissue reaction to the secretion injected into them while the parasites are feeding. The secretions in some cases may cause certain cells to coalesce to form a so-called giant cell. This can result in galls or enlargement of the root at the nematode feeding site.

Above ground symptoms caused by the root-feeding nematodes are similar to any condition that deprives a plant of an adequate and proper functioning root system. Affected plants may lack vigor, foliage may become yellow, and may, if the root system is heavily damaged, wilt and die. In some cases there is slow decline which may result in greatly reduced yields. Infestations may be localized at first, then gradually spread to other parts of the field. When root systems are carefully examined, root-knot nematode damage appears as enlarged and knotty roots. When the soybean cyst nematode is present, very small pearl white bodies may be observed attached to the roots, or if examined with a hand lens, the brown cyst stage will appear as lemon-shaped bodies on the damaged roots. Most kinds of nematodes are difficult to see when the plants are examined and positive identification must be made under laboratory conditions.

SPREAD

Soybean cyst nematodes may be spread by movement alone or in infested soil associated with farm implementes, plants, animals, birds, wind, and run-off water. They can move only a few feet each year by their own efforts.

HOW MUCH ARE NEMATODES COSTING SOYBEAN GROWERS IN THE U. S.

Since soybeans are a relatively new commercial crop in the U. S., it has only been in the past 25 years that special emphasis has been devoted to the study of nematodes that affect this crop. Much research data have been obtained on the extent of damage caused by plant parasitic nematodes. Enough data are available to conclude that losses amount to about 10% of the total crop (11). A careful study of the loss to the crop published in 1971 showed that the average loss from 1962 to 1968 amounted to $252,000,000 (8). Since 1968, the acreage planted to this crop has increased and based on the acreage in 1973, the loss would be well over $300,000,000.

Now that soybeans are planted on the same fields each year it appears that certain nematode populations are increasing and loss to the crop is also increasing.

DISTRIBUTION OF NEMATODES THAT ATTACK SOYBEANS

There are many kinds of nematodes that attack soybeans. Soybeans require a warm climate for maximum production. Most plant-parasitic nematodes thrive best when the soil temperature is optimun for good soybean growth. Many of the nematodes that attack soybeans can live and reproduce on other kinds of plants. It is obvious that certain kinds of nematodes may be present in the soil when soybeans are planted for the first time. The kinds and numbers present in the soil can have an important impact on the yield.

On the basis of reports of workers in many countries, it can be concluded that soybeans are excellent hosts for nematodes. They are known to occur in all tropical countries where they damage many crops.

CONTROL OF NEMATODES OF SOYBEANS

Data are available to show that most of major nematodes of soybeans can be controlled and that near normal yields can be obtained if the control methods are properly utilized:

(A) Control by rotation: Most nematodes have a short life span and if they do not obtain food from a host they will not persist for very long (5). When non-hosts of a nematode are planted for 2 or more years, most of the nematodes will die and when soybeans are planted following this, a good yield may be the result (7). It is a good practice to fallow the land for one or more years to starve the nematodes. This is not practical where the suitable land for soybean production is limited. In rotations to control root-knot nematodes, oats and crotalaria are the only crops that are best suited for use. With soybean cyst nematodes, cotton, corn, and milo are excellent crops to use in a one-, two-, or three-year rotation.

(B) Chemical Control: Nematicides are the most effective and reliable means of controlling a wide variety of nematodes (10). Suitable application methods have been devised for applying about 20 highly effective nematicides and soil fumigants (12). Only a few chemicals have been cleared for use to control nematodes of soybeans. Nematicides have been used very extensively to control nematodes of soybeans due in part to the high cost of the nematicide and cost of application. Until recently soybeans have been considered a low income crop.

DBCP (1,2-dibromo-3-chloropropane), Mocap (O-Ethyl S,-S-dipropyl phosphoroditioate), Temik (2-methyl-2-(Methylthio) propionaldehyde O-(Methylcarbamoyl) oxime), Nemacur (Ethy 4- (methylthiom-tolyl isopropyl phosphoramididate), and Furadan (2-3-dihydro-2, 2 dimethyl-7-benzofuranyl methylcarbamate), have been effective for control of the soybean cyst and root-knot nematodes of soybeans (Table 1). Temik, Furadan and Nemacur have not been cleared for use to control nematodes of soybeans. At the present time DEBCP and Mocap have clearance for soybeans.

DBCP and Mocap can be applied at time of planting. These two chemicals differ in their mode of controlling nematodes. Mocap is a contact nematicide and must be incorporated into the top 5 to 6 inches (10-15 cm) of the soil. DBCP is a fumigant and should be injected in the row to a depth of 6 to 8 inches (15-20cm). The cost of these materials is approximately $10 per acre ($24 per hectare).

(C) Use of resistant varieties: Excellent control of some kinds of nematodes of soybeans can be obtained by planting varieties with resistance to one, two or three kinds of nem-

TABLE 1. YIELD (BU./A.) FROM NEMATICIDE TREATMENTS 1970-73

		Race 3			Race 4		
Treatment	ai./A.	1970	1971	1972	1971	1972	1973
Mocap (12"B)	3 lbs./A	34	22	31	35	23	29
" "	6 " /"	32	22	33	46	21	27
Nemacur "	1.7 " /"	31	21	35	43	25	30
" "	2.6 " /"	34	28	36	39	23	28
Furadan "	2.0 " /"	36	28	39	40	25	33
" "	2.0 " /"	39	25	37	30	19	--
Temik (Drill)	.6 " /"	--	--	36	--	21	29
" "	.9 " /"	--	--	36	--	20	28
DBCP "	3 qts./A.	--	35	35	41	31	32
" "	4 " /"	--	32	40	34	25	26
Lee 68 untreated		31	15	36	31	20	28
Pickett 71 "		43	29	45	36	20	24
Forrest "		--	44	46	29	17	28
LSD 5%		9.2	10.0	6.4	10.6	NS	NS
LSD 1%		10.4	14.6	7.3	14.1	--	--

atodes (Table 2). It has been known for a long time that some varieties were resistant to root-knot nematodes (2). The varieties Laredo, Illsoy, Hardee, Jackson, Bragg, Forrest, Hampton, Delmar, Dyer and Hill are some of the many that are known to have resistance (2). The varieties Peking, Pickett, Pickett 71, Dyer, Custer, Mack, and Forrest have good resistance to races 1, 2, and 3 of the soybean cyst nematode (1, 13, 14, 15). These varieties are well adapted for production in areas where races 1, 2 and 3 occur. These resistant varieties obtained their genes for resistance from the Peking variety (1, 14, 16).

In 1968, Race 4 of the soybean cyst nematode was identified from the state of Arkansas. This race attacks all commercial varieties that have resistance to races 1, 2, and 3. When some of the entries in the germplasm collections were screened for resistance to this new race, three plant introduction entries were found to have good resistance to this race. At the present time research to develop resistance to this race has high priority. Some promising selections are being evaluated from crosses with the resistant material and varieties having good resistance material and varieties having good resistance to the other races and root-knot nematodes.

Each method of control has its weakness: Rotation - The grower may not be able to use another crop that will reduce the nematode population. Rotation with a crop may lead to the continued build-up of the nematode population; Chemicals - Use of Chemicals for several years may lead to a strain of the nematode that would not be affected. This has happened on numerous occasions where insects build up resistance to certain chemicals; Resistant Varieties - When a resistant variety is planted repeatedly there is a chance that a strain of the nematode may develop that will attack the resistant varieties. This may be what has happened where race 4 of the soybean cyst nematode has become established.

SUMMARY

Plant parasitic nematodes are a major factor where soybeans are grown. They cause reductions in yields estimated at 10% of the crop. There are more than 20 kinds that are capable of reducing yields. They damage the root systems of soybeans resulting in poor growth and in some cases death of the plants. There are many ways they can be spread to new locations. Three methods have been used successfully to control nematodes, namely, rotations, chemicals, and resistant varieties. These methods are not permanent and their usefulness is

TABLE 2- REACTION OF SOYBEAN VARIETIES TO 9 KINDS OF NEMATODES

Soybean Variety	Maturity Group	M. incognita	M. javanica	M. hapla	M. arenaria	H. glycines Race 1, 2, & 3	H. glycines Race 4	R. reniformis	Belonclaimus	Hoplolaimus
Blackhawk	I	MR		R		S	S			
P.I. 88,788	III	R				R	R			
Custer	IV	S				R	S	R		
Peking	IV	S				R	MR	R		
P.I. 90,763	IV	S				R	MR			
P.I. 88,772	IV	S				R	R			
Bethel	IV	MR				S	S			
Dare	V	MR				S	S			
Dyer	V	R	S	S	MR	R	S	R		
Forrest	V	R				R	S	R		
Illsoy	V	MR		MR		MR	S			
Hill	V	R				S	S			
Mack	V	S				R	S	S		
Pickett 71	VI	S				R	S	R		
Pickett	VI	S				R	S	R		
Laredo	VI	R				S	S			
Bragg	VII	R			MR	S	S	S	MR	
Jackson	VII	R			S	S	S			
Pinedell	VII	S	MR			S	S			
Ronoke	VII					S	S			MR
Palmetto	VII	MR				S	S			
Hardee	VIII	MR				S	S	S		
Hampton	VIII	MR	MR			S	S			

R - Resistant; MR - Moderately Resistant; S - Susceptible

limited to the kind of nematode and availability of crops to use in rotation, proper use of chemicals, and varieties with resistance suitable for production where the infestations occur.

I believe it is possible to grow soybeans in all areas they are adapted regardless of the kind of nematode that is present if special efforts are made to utilize available research. In order to keep abreast of nematode problems, there is a need for research, especially on breeding for resistance to nematodes of this crop.

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INSECT PESTS ON SOYBEANS

Marcos Kogan 1/

Los insectos y ácaros causan diversos daños a las soyas, variando de acuerdo a los hábitos de alimentación y los requisitos ecológicos de cada especie. Hay especies adaptadas para atacar la planta en todas sus etapas de desarrollo. Es importante determinar la intensidad del daño producido por los insectos necesario para llegar a causar una pérdida económica. Esto es de fundamental importancia para el desarrollo de programas de manejo de plagas. Se discute el sistema empleado para esos fines por la Universidad de Illinois, en un intento por resolver el problema y con el propósito de usarlo como guia en el desarrollo de un programa de manejo de plagas en soyas. Se emplea como ejemplo el efecto de la defoliación en la merma en producción y el papèl que juega el enrollador de la hoja soya, Pseudoplosia includens, en ese proceso de defoliación. Haciendo uso de información ya publicada y simulando la defoliación y su efecto en la producción, se logró diseñar unas fórmulas matemáticas para determinar los niveles económicos del daño producido. Aunque esta fórmula fue desarrollada para zonas templadas, se cree que puede ser fácilmente adaptada para mejorar la eficiencia del control de plagas en soyas en los trópicos y subtrópicos.

Insects and mites cause injury to soybeans in ways that vary with the particular feeding habits and ecological characteristics of each species.

There are species that injure the plants through 1) defoliation, 2) debranching or breakage of whole plants, resulting from stem feeding, 3) blossom destruction, 4) pod and seed destruction (Figure 1). Other less evident types of injury result from 1) feeding on roots and nodules, 2) piercing and sucking of green seeds, causing seed malformation and consequent reduction of seed quality, 3) transmission of pathogenic organisms.

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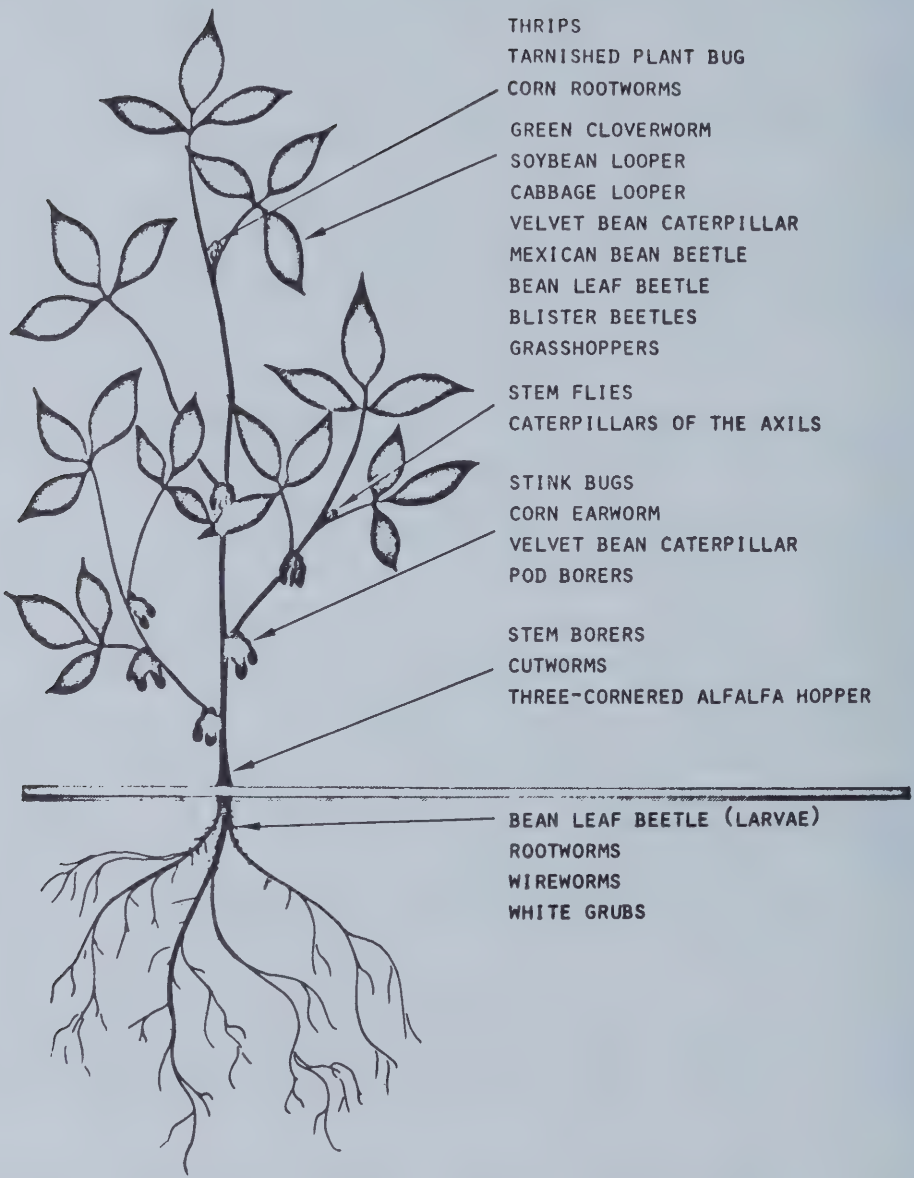

Fig. 1. Virtually every organ and part of the soybean plant is attached by one or more species of arthropods.

There are species adapted to attack the plants at every stage of development (Figure 2). At germination and during the early seedling stages insects attack below and above ground level. Among others, there are larvae of flies known as seed corn maggots that destroy cotyledons and top whole seedlings.

As plants develop, certain species start feeding on roots and nodules like bean leaf beetle larvae, white grubs and wireworms.

During vegetative growth the defoliators, such as the velvetbean caterpillar, soybean loopers, leaf beetles, blister beetles, grasshoppers, start to appear and continue to attack throughout the blooming and podding stages.

Blossoms are destroyed by *Lygus* bugs, thrips, and certain flower beetles, and finally the pods themselves are subject to attack by stink bugs, bean beetles, grasshoppers, and several species of pod borers, of which the corn earworm is one of the most conspicuous.

Although the dominant species vary from region to region, there are ecological homologues that occupy the same niches in the agroecosystem in the various parts of the world.

E.g., stems of soybeans are bored by the long-horned beetles, *Dectes texanus* in the USA, *Oberea brevis* in India, and *Corrhenes paula*, and *Zygrita diva* in Australia, and by the caterpillar of the moth *Crochiphora testulalis* in South America.

Soybeans, however, have a great capacity to recover from or to compensate for injury:

E.g.,
1) The number of pods per node increased from 4 on the main stem, and 1.5 on the branches to 5.7 pods per node on debranched plants (Beuerlein *et al.*, 1971).

2) Removal of up to 40% of pods at early pod fill stage had little effect on yield, probably due to the fact that the seed formed was generally heavier in depodded plants (Smith and Bass, 1972).

3) Abortion of flowers is a natural tendency of the plant which normally uses no more than 25% of the blossoms that are formed. Therefore, even a moderate level of blossom destruction by insects is not likely to greatly contribute to this natural event.

4) Artificially defoliated plants respond differently ac-

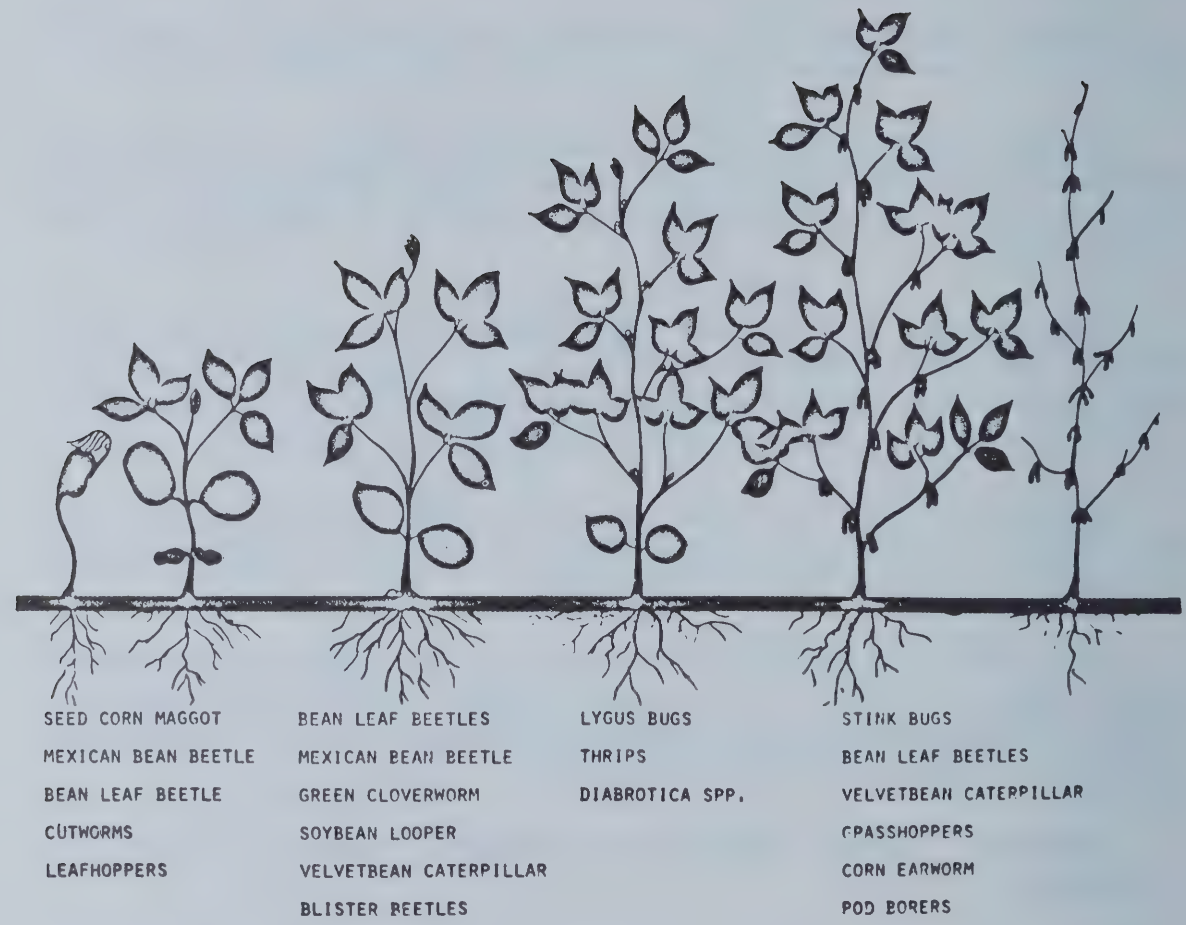

Fig. 2. Each stage of soybean development is attached by a complet of arthropod species. The synchronization of the plant's growth patterns with the insects phenology is essential for the species to become a pest.

cording to the level of defoliation, and according to the stage of development of the plant when defoliation occured. I will elaborate on this aspect later in this discussion.

What then is the level of injury by insects that will cause an economic loss - and how is this economic loss assessed?

This question probably is the crux of modern economic entomology, and its correct answer is absolutely fundamental for the development of pest management programs.

I will discuss the approach we are taking at Illinois to solve the problem and to use the information in a set of guidelines for a pest management program in soybeans. To simplify the discussion, I will use as example the effect of defoliation on yield reduction and the role of one species - the soybean looper, Pseudoplusia includens, in the defoliation process.

There is vast literature correlating simulated defoliation with yield reduction. Some of the early work has been done at Illinois by Dungan, Fuelleman and others in the early 40's, but perhaps the best data available are from the work by Kalton, Weber and Eldridge (1949) done at Ames, Iowa, using the varieties "Lincoln" and "Richland." These studies were made to help hail insurance adjustors to assess damage caused by hail storms.

The work on hail damage was picked up by entomologists in the last 5 years, and several experiments were conducted in Florida, Missouri, Alabama, South Carolina, and in Georgia, to validate previous work, and to gather information on problems more peculiar to insect caused defoliation.

Combining the data contained in about 10 reports on defoliation it was established that:

1) The effect of defoliation varies significantly with the stage of development of the plant.

2) Plants are most susceptible to defoliation at the pod setpod fill stage (R3-R5).

3) Second-degree curves can be fitted to the existing data to describe the relationship of defoliation with yield reduction.

We need also information to establish the correlation between the

level of soybean looper populations with percent defoliation of soybean plants.

We measured the amount of soybean foliage consumed by the caterpillar necessary to complete larval development. The larvae gained 353.6 mg fresh weight and consumed 1.626 mg of fresh, young, soybean leaves ("H arosoy"). The food weight was converted to area and we found that each larva ate from 120 to 180 cm^2 of foliage.

Defoliation caused by the soybean looper differs from the simulated defoliation in a number of ways:

1) Larval feeding extends over a period of two to three weeks whereas simulated damage is usually inflicted on one operation.

2) Larval damage frequently results in the removal of many small areas of the leaf, whereas most simulated damage work is done by removal of entire leaflets, and

3) During the time in which the larva is feeding, the plant is growing, therefore compensation starts even while damage is being inflicted.

Despite these incongruencies, we can use the data on the correlation of simulated defoliation with yield loss, and the data on foliage consumption by the caterpillars in preliminary models to define the most critical parameter in a pest management program, namely the economic injury level, which is the "lowest pest population density that will cause economic damage" (Stern et al., 1959) or "the (pest) population that causes incremental damage equal to the cost of preventing damage" (Headley,1972). In fact, control measures should be applied before the economic injury level is reached and this critical time for making precautionary treatments is known as the economic threshold.

In practical terms, we need a method for defining the population of soybean loopers (in our example) that, if left unchecked, will eventually cause an amount of damage that will reduce the potential yield by an amount greater than the cost of the control measures. Therefore, the cost of the control will be more than offset by the corresponding gain in yield.

At this point entomological considerations intertwine with economic considerations.

A mathematical expression has been derived by Dr. W. G. Ruesink, from the Illinois Natural History Survey, that allows us to estimate economic injury levels for insect defoliations provided we know:

1) The leaf area consumed by individual larvae. (F)

2) The mean total leaf area present per plant at a given stage of development. (L_o)

3) The coefficients of the quadratic equations that correlate defoliation with potential yield loss (α and β).

4) The cost of treatment of a unit area (C_2-dollars per acre in this case).

5) The estimated yield (in bushels per acre).

6) The current price of beans (in dollars per bushels)

The simplified form of the equation is:

$$P = \frac{.005Lo}{\beta \Sigma F}\left[-\alpha + \sqrt{\alpha^2 + 400\left(\frac{\beta C_2}{NoC_1}\right)}\right]$$

where P = population level at economic threshold.

Using this expression, I calculated a series of economic threshold populations for the soybean looper attacking soybeans during the period of (1) vegetative growth up to stage V5, (2) during bloom (R2), (3) during pod-set and pod-fill (R3-R5), and (4) during seed maturation (R7-).

The following constraints were imposed in these calculations:

1) There was no previous defoliation.

2) There was no larval mortality during the period of feeding (about 2 weeks).

3) The plants did not grow during the period of feeding (about 2 weeks).

The following values were used:

A potential yield of 36 bushels per acre (No)

The food consumed by the looper was 120 cm^2 (F)

The total foliage area present (Lo) was:

500 cm2 during early vegetative growth
1, 027 cm2 during bloom
2, 729 cm2 during pod-set and pod-fill
4, 023 cm2 during seed maturation

The price of soybeans was allowed to vary from \$3.00 to \$10.00 per bushel.

The figure shows the relationship between the economic threshold and the price of soybeans: At \$3.00/bu we can tolerate a population of near 20 larvae per foot of row at stages V5 and R2, 13 larvae at R3-R5, and 62 larvae at R7. At \$6.00/bu, however, we can tolerate only 16 larvae per foot row at V5, 10 at R2, 6 at R-3-R5, and 30 at R7.

If we had a linear relationship between price increase and threshold decrease and a unit slope, then we would expect the threshold levels to decrease by one-half as prices doubled. But this relationship does not occur. The use of this concept may represent savings of millions of dollars in cost of unnecessary treatments, and even more if we consider the burden that pesticides represent in the environment.

Subsequently, the established economic thresholds have to be incorporated into pest management procedures. We attempted to do this at Illinois by correlating what we know about the growing patterns of the crop with the phenology of some of the key insect pests in the region.

The graphs are prepared to indicate the critical phases of the culture at which insect problems may develop. It is then recommended that fields be scouted during these critical phases and that samples be taken to evaluate the mean percent defoliation in the field and the mean number of individuals per foot row. Guidelines were prepared using current pesticide recommendations to control populations that exceed the computed economic thresholds.

If we examine again the equation for this model, we see that alternative control methods can be proposed to either allow the plants to tolerate a higher population of the pest, or to reduce the amount of foliage consumed.

The value of P will be altered by any of the following events:

1) If Lo, the total leaf area present, increases.

2) If α and β are changed to approach a straight line with the slope approaching zero.

3) If F - the foliage consumed is reduced.

The effect of increased Lo the amount of foliage present is apparent when we observe the indeterminate varieties growing in the midwest. We measured in excess of 4.000 cm^2 of leaf area in "Clark 63" plants, whereas in other areas plants have less than 2.000 cm^2 of leaf area.

Most control measures are aimed at reducing F - the amount of food consumed by reducing the larval population with: the use of pesticides, the use of parasites and predators in biological control programs, the use of microbial pathogens, and finally the use of resistant varieties, some of which affect larval survival.

Changes in the characteristics of α and β are less likely to be achieved because they are inherent in the physiology of the plants.

Although developed for the ecological conditions of the American Midwest, I believe that this approach can help improve the efficiency of pest control on soybeans in the tropics and sub-tropics. Insect problems in these regions are generally more severe than in the more temperature climates. But the fundamental concepts exposed here are applicable to virtually any agroecological conditions. What we need is the basic information to derive the parameters of the system. In summary,these parameters are:

1) The growth patterns of the soybean plant under tropical and sub-tropical conditions.

2) The correlation between yield loss and damage (defoliation, debranching, etc.).

3) Measurement of the food consumed by the key pest species.

4) A detailed survey of the life history and phenology of the key pests.

Those 4 topics may very well serve as a matrix for new entomological programs to be developed in areas with expanding soybean production. Although the system is over simplified at this point we are working to make it more flexible, more dynamic, and therefore, more realistic. The feedback from the implementation of the program will greatly help to improve it and to give it a more general value.

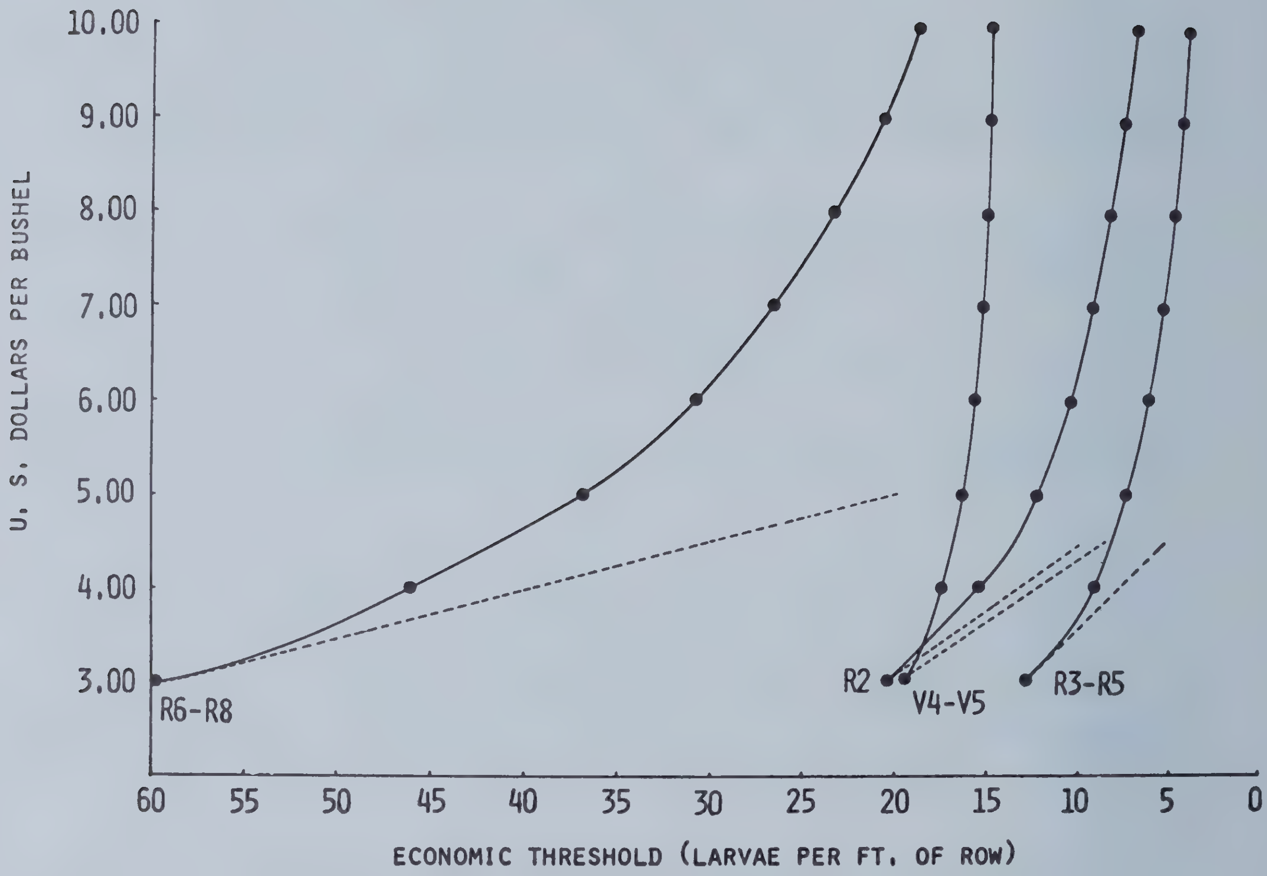

Fig. 3 The economic threshold of the soybean looper on soybeans is influenced by the price of soybeans in a non-linear form.

THE INTERNATIONAL REFERENCE COLLECTION OF SOYBEAN ASSOCIATED ARTHROPODS

George L. Godfrey[1/]

La Colección Internacional de Referencia para Artrópodos Relacionados con las Soyas es un recurso que viene a reforzar las actividades locales e internacionales del Programa Internacional de Soyas (INTSOY). Es, además, un recurso de servicio que puede utilizarse por otras organizaciones e instituciones para sus respectivos programas con soyas. La colección, que se originó en el 1969, y cuenta con la ayuda de 40 instituciones y 50 individuos, ha recibido material de 22 países y 21 estados de los E.U. Se han recibido e identificado aproximadamente 50,000 especímenes que representan 1,300 especies. Ha alcanzado además, una etapa de desarrollo tal que permite la preparación de manuales de identificación de especies para las áreas geográficas cubiertas por catastros. La compilación de nombres de especies se usarán para desarrollar un catálogo de artrópodos de las soyas. Estas son dos de los objetivos de la colección que se están convirtiendo en realidad.

The functions of collections containing insects and related arthropods and the position of taxonomists in agricultural research occasionally are not clearly understood by administrators and researchers in allied fields. This is not too surprising because I could even name some entomologists who share similar thoughts. Two reasons for this are: (1) taxonomists frequently fail to maintain open paths of communication with other research staff personnel and (2) nontaxonomic agricultural scientists sometime do not fully comprehend that insect collections are a resource tool; furthermore, they often do not know how best to utilize taxonomic knowledge in their research.

Let me briefly say that an insect collection is somewhat analogous to a library card file. The key to obtaining pertinent information beyond any given specimen is the specific name. Thus, before extracting any information, published or unpublished, it is important that the insect is accurately identified. Dr. Marcos Kogan just explained to you the necessity of determining the threshold of economic damage

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before deciding if controls are warranted. If control efforts are started without knowing the correct identity of the target species, various problems can arise. For example, if two closely related insects are damaging a crop but recognized as only one species, any parasite released for the correctly identified species might very likely be ineffective against the unrecognized insect either because of the parasite's host specificity or because of the lack of synchrony of the life histories of the parasite and the second pest species. I don't have time to develop this further, but I think the point has been made.

Competent taxonomic services will be available to agriculturalists so long as there is adequate support for persons in this area. There must be support for educating persons at the graduate school level in the basics and theories of taxonomy, and support for applied services after graduation.

Within recent years, there has been a growing demand for taxonomic services from agriculturalists, ecologists, industrialists, etc. The demand has grown faster than the "birth rate" of taxonomists. The Association of Systematics Collections (ASC) has been critically studying this situation. A report titled "America's Systematics Collections: A National Plan (Prepublication Draft)" was issued in August, 1973. A major concern of ASC, as stated in its report, is to improve financial support for collections so that they can become"... a more effective resource responsive to the needs of science, applied science and society." An effort of ASC also will be to"...develop criteria for the identification of collections of national importance and a mechanism for designating collections and institutions according to a classification and supporting criteria." The report lists four possible classifications. One is "Systematic Service Centers" that would include the following facilities:

1. Sorting Centers--to provide "preliminary sorting for massive collections, especially those acquired for large ecological programs..."

2. Identification Centers--"to provide routine identifications and coordinate identification services by specialist for more difficult groups."

3. Specialized Service Centers--to provide data bank facilities.

4. Natural History Information Centers--to provide data bank facilities.

5. Natural History Information Centers--"to screen inquiries and provide information. . . to answer the kinds of questions most frequently asked . . ."

When I first read this report one month ago, I saw many parallels between the International Reference Collection of Soybean Associated Arthropods and the "Systematics Service Center" just described.

The concept of a world-wide collection of soybean arthropods was formulated by my colleague, Dr. Kogan, in the fall of 1969. International interest in soybean consumption and the supporting agricultural research was rapidly increasing at that time; perhaps not as fast as it is now, but nevertheless it was rapid. Foresight by Dr. Kogan saw the need to survey the soybean fauna on a world-wide basis for particular needs that I will discuss momentarily. Since then we have proceeded to document the soybean arthropods, especially the insects. Our goal is to determine what plant-feeding insects presently occur on soybeans and what the parasites and predators are of the phytophagous species throughout the world. This will establish baseline data and information that will (1) permit the monitoring of key pest species for possible changes in distribution, (2) be useful to researchers developing pest-management programs, (3) aid in predicting major insect problems in areas where soybeans are newly introduced, and (4) provide identification services for international researchers. The identifications are handled by the personnel associated with the collection and through the network of identification channels that have been developed. There presently are approximately 40 institutions and 50 individuals who assist us.

The development of the collection has proceeded along cooperative channels. We have solicited survey samples from many institutions and individuals and, in return, have provided the following services:

1. A list of the species in the samples after they are identified.

2. A representative set of identified species from the samples, if a set is requested.

3. Assistance with singular specimen identifications.

4. Assistance with literature requests through our Soybean Information and Research Center.

Using this approach, we have received material from 22 countries, plus 21 states in the U.S. To date, approximately 50,000 specimens representing 1,300 species have been received and identified. Our immediate goal is to intensively survey soybean fields in Latin America. We have a reasonably good start through the contributions from Argentina, Belize, Colombia, and Mexico.

The International Reference Collection of Soybean Associated Arthropods is housed in the facilities of the Illinois Natural History Survey. This institution maintains an arthropod collection of approximately five million specimens. This is one of the largest state supported collections in the U.S. This sizable collection has greatly aided the development of the soybean arthropod collection. The taxonomists of the Illinois Natural History Survey are available for consultation and have contributed to the soybean program.

The samples received by the International Reference Collection of Soybean Associated Arthropods are accompanied by a standarized data sheet pertaining to important ecological, meteorological, and agricultural factors. The information is stored on computer tapes for future retrieval and analysis. The field samples are processed through a sequence of sorting, labelling, identification, and data tabulation. The total number of specimens per life stage per sample is also stored for future use. Through the computer facilities and programs available to the collection, many different kinds of species lists can be obtained in relation to the field data. The data are being used to correlate the complexes of soybean insect communities with environmental factors, including soybean varieties.

In summary, the International Reference Collection of Soybean Associated Arthropods is a resource base supporting the domestic and international activities of the International Soybean Program (INTSOY). It is also a service resource base that may be utilized by outside organizations and institutions for their respective soybean programs.

The collection has reached a level in its development that regionalized insect identification manuals can be prepared for the geographical areas that have been adequately surveyed. The compilation of species names through the surveys and literature searches will be used to develop a catalogue of the soybean arthropods. These are two of the major objectives of the collection that are becoming a reality. The success of the collection and of many of the ongoing soybean research programs depends on cooperation and communication. Your comments and suggestions for improving the goals and services of the collection are welcomed.

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PRODUCCION DE SEMILLAS EN COLOMBIA 1/

Fernando Gómez M. 2/

INTRODUCCION

Dentro de las estrategias trazadas para alcanzar una mayor producción y productividad agrícola, las semillas mejoradas constituyen un factor de especial importancia no solo por su impacto directo en la productividad de los cultivos sino por su influencia en el éxito de la aplicación de los demás insumos que conforman el paquete tecnológico. Esto significa que la rentabilidad en el uso de fertilizantes, plaguicidas, mecanización, mano de obra especializada, riego y los otros insumos que intervienen en la producción moderna estará notablemente limitada si no se usan aquellos materiales de propagación mejorados que son la base de los mejores rendimientos y calidad de las cosechas.

Lo anterior tiene su fundamento en el hecho de que la semilla mejorada a diferencia de la común o criolla, tiene un origen conocido y ha sido sometida a un proceso de selección genética para aumentar su capacidad productiva, la resistencia a plagas y enfermedades o mejorar sus cualidades agronómicas para facilitar su crecimiento o posterior uso de tecnologías avanzadas.

Se destaca entonces, la importancia de estudiar a fondo los aspectos referentes a la producción, distribución, consumo y demás factores relacionados, con el fin de facilitar los elementos indispensables para la programación de la producción agropecuaria del país. Limitados por la escasa y deficiente información, este capítulo contribuye a la clarificación y formulación de recomendaciones sobre los tópicos antes mencionados que constituyen parte fundamental de la política agraria nacional.

1. Organización y Política

El Decreto 140, promulgado por el Gobierno Nacional en 1965, es el documento básico de la legislación Colombiana en materia de semillas y ha servido para establecer politicas muy definidas al respecto. En cuanto a lo primero ha originado un programa de certificación de

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1/ Contribución del Servicio de Semillas del ICA
2/ Ingeniero Agrónomo, Director del Servicio de Semillas del ICA.

semillas que ha sido fundamental para establecer un control de la pureza física y genética de las variedades o híbridos mejorados que se comercializan en el país, sean éstas de origen oficial o particular. En cuanto a lo segundo, ha permitido a la iniciativa privada iniciar programas de multiplicación y comercialización de semillas, originando de esta forma una industria privada que funciona sobre los principios de la libre empresa.

La política anteriormente formulada, ha sido eficientemente implementada con una reglamentación sobre producción y certificación de semillas. Su elaboración se ha basado en los resultados de la experiencia práctica en cada cultivo, de suerte que hoy el pais cuenta con una ligislación en semillas que se ajusta perfectamente a las necesidades propias de Colombia. Seguramente con el tiempo, y a medida que las circunstancias lo exijan, los requisitos mínimos de calidad se modificarán adecuadamente, pero siempre fundamentados en nuestras propias experiencias.

2. Calidad de la semilla

La razón de ser de un programa de certificación tiene como objetivo fundamental producir semillas de óptima calidad. Esta, debe entenderse como la suma de todos los atributos físicos y genéticos que le permitan a una semilla establecerse en el campo para producir plantas que producen abundantes alimentos o materias primas para la industria.

Dentro de este proceso de certificación, es necesario recorrer varias etapas que son esenciales para garantizar la calidad final de la semilla que llega a manos del agricultor para su siembra. Después de esta parte previa, viene la ejecución propia de los planes de multiplicación. Estas, logicamente deben realizarse de acuerdo con los requisitos específicos de campo y laboratorio propio de cada cultivo.

Registro de Variedades

La primera parte de este Programa de certificación de semillas se refiere al registro de las variedades mejoradas que se producen en el país por parte de los programas oficiales de mejoramiento genético, la empresa privada o ambos.

Para el registro de una nueva variedad se requiere informar acerca del originador, genealogía del material, adaptación y sus características agronómicas más importantes.

Características Agronómicas más importantes:

En el caso de semilla certificada de soya, el país cuenta con las variedades ICA Lilly, Pelican S. M. ICA, ICA-Taroa, Mandarín e ICA-Ponce. Algunas de sus características agronómicas más sobresalientes se presentan en las Tablas 1, 2 y 3.

Tabla 1. Adaptación y otras características agronómicas de las variedades mejoradas de soya en Colombia.

Nombre	Adaptación m.s.n.m.	Período Vegetativo
ICA ·Lily	900-1000 m.	100 - 105 days
Pelican S.M. ICA	900-1000 m.	100 - 105 days
ICA-Taroa	900-1100 m.	95 - 105 days
Mandarín	900-1000 m.	115 - 130 days
ICA - Pance	900-1200 m.	95 - 100 days

Tabla 2. Otras características agronómicas de las variedades mejoradas de soya en Colombia.

Nombre	Peso de 100 semillas (grs.)	Rendimiento Experimental (Kgs./Ha.)
ICA Lily	19	2.680
Pelican S.M. ICA	17	2.500
ICA-Taroa	20	2.500
Mandarín	19	2.500
ICA-Pance	19	3.400

Tabla 3. Otras características agronómicas de las variedades mejoradas de soya en Colombia.

Nombre	Altura de Planta	Color de flores
ICA-Lily	0.80 m.	blanco.
Pelican S.M.ICA	0.90 m.	lila
ICA-Taroa	0.60 - 0.65 m.	lila
Mandarín	0.90 - 1.0 m.	lila
ICA-Pance	0.45 - 0.50 m.	blanco

Registro de productores

La segunda parte del programa de certificación es el registro de productores. Este registro es dado solamente a aquellas personas o entidades que poseen el equipo mínimo necesario para el procesamiento de semillas, tienen personal técnico idóneo, van a producir semilla de aquellas variedades que han sido registradas previamente y aceptan todas las condiciones y requerimientos de calidad establecidos previamente en las Resoluciones que posee el Gobierno por cada cultivo. En soya, el país cuenta con 5 productores de semilla certificada con igual número de plantas destinadas al procesamiento mecánico. Esta situación le brinda a Colombia una capacidad instalada de 8,000 toneladas-año de semillas que está siendo utilizada en un 93%.

Producción de semilla

El cultivo de soya en el trópico requiere de condiciones ecológicas muy especiales, que en el caso de producción de semilla revisten una mayor importancia. Quizás, este punto sea una de las razones por las cuales el cultivo de la soya se encuentre restringido en Colombia al Valle del Cauca. Esta región del país cuenta en el trópico con características muy especiales que favorecen dicho cultivo, tablas 4,5,6 y 7.

Tabla 4. Geografía del Valle del Cauca.

Altitud	:	972 metros sobre el nivel del mar
Latitud	:	Norte : de 3° a 4° 40' Longitud: Oeste, de 7° 10' a 77° 20'
Area	:	300.000 hectáreas

Tabla 5. Clima del Valle del Cauca

Precipitación promedia anual	1.140 mm.
Temperatura promedia anual	24^{o} C.
Humedad relativa promedia anual	75.6 %
Variación diaria de la humedad relativa	de 26% a 100%

Tabla 6. Epocas de siembra

Semestre	Fecha	Lluvia
Primero	Marzo 10 a Abril 20	Marzo-Mayo
Segundo	Septiembre 15 a Octubre 20	Octubre - Noviembre

Tabla 7. Composición típica de los suelos donde se cultiva soya en Valle del Cauca en Colombia.

Textura	Franco limoso
Ph	6.90
Capacidad catiónica de cambio	29.36 m.e.q./100 grs de suelo
Contenido de K_2O	310 Kgs./Ha.
Contenido de materia orgánica	1.9%
Nitrógeno total	0.15 %
Relación C/N	7.1
Contenido de P_2O_5	16.68 Kgs./Ha.

Si se observan las Tablas 8,9 y 10, se encuentra que las áreas sembradas con soya no presentan variaciones significativas en los dos últimos años referidos. Así mismo las proyecciones de producción de soya para 1974 no muestran un incremento muy significativo. Precisamente, con el criterio de ampliar las áreas productoras de soya en Colombia, el Programa de Mejoramiento de Plantas del Instituto Colombiano Agropecuario ICA, ya se encuentra adelantando los estudios correspondientes.

Tabla 8. Producción de semilla de soya de las variedades mejoradas usadas en Colombia en 1972 y 1973. 1/

Variedad	Año 1972		Año 1973	
	Tons.	Has. sembradas	Tons.	Has. sembradas
Pelican S.M. ICA	1.177	15.689	1.691	22.546
ICA-Lily	1.848	24.644	1.781	23.753
ICA-Taroa	199	2.652	16	213
Mandarín	18	239	73	971
ICA Pance *	-	-	-	-
TOTAL	3.536	47.145	3.779	50.378

1/ Densidad de siembra

* Entregada en Julio de 1973

Tabla 10. Densidades de semilla de soya para el programa de siembras en 1974.

Año	Hectáreas Sembradas	Hectáreas sembradas con semilla certificada	Por ciento de utilización
1972	58.000	47.145	81.2
1973	63.000	50.377	79.9

Tabla 9. Hectáreas sembradas con semilla certificada de soya en 1972 y 1973

Semestre	Area a sembrar Has. 1/	Necesidades de Semilla (Tons.)
A	23.467	1.760
B	34.133	2.560
TOTAL	57.600	4.320

1/ = Densidad de siembra: 75 Kgs./Ha.

WRAP-UP DISCUSSION OF SOYBEAN PRODUCTION

R.W. Howell, 1/

The INTSOY concept, as we realize from the last two days' discussion, encompasses the globe. The soybean, with its marvelous complement of protein, is a unique resource in mankind's search for adequate nutrition. It is without peer as a conduit to convert the energy of the sun and the nitrogen of the air to high energy, highly nutritious food and feed.

The portion of the INTSOY program which has been funded so far has enabled the Universities of Puerto Rico and Illinois, under sponsorship of USAID, to begin the assembly of staffs and the building of programs with specific responsibility for soybeans for tropical areas. INTSOY is the latest expression of the commitment to international agricultural development in which these universities and others have been engaged for many years.

The soybean has been a major crop, a dietary staple, for many millennia in China. Within a few decades it has become the golden crop in the temperate zones of North America. It is on the verge of vast importance in South America. These records were built on many favorable circumstances - not least that the product is of incomparable worth and the species can be widely adapted.

These successes show what can be done. Most soybean technology is technology for the temperate zone. That is where most research and educational investment has been made. Some of the technology is transferrable to the tropics, some is not. The people, the needs, the climate, the soil, and the hazards here are different. Research and education must develop and establish soybean technologies for the unique needs of the tropics.

The task is not to begin. We have already begun. The scope and depth of papers, the diversity of sources, and the contributions of participants here are eloquent testaments of the beginning. Soybeans can be produced in the tropics. That is a known.

1/ Professor and Head, Agronomy Department, University of Illinois at Urbana-Champaign.

So the challenge, the opportunity and the drama are before us. This conference has opened new avenues of dialogue and has strengthened others.

INTSOY can provide a focus through which the community of soybean researchers may join efforts.

INTSOY aspires to a major role in the development of soybeans for adaptation and use throughout the world.

INTSOY is a dream, as was said at the start, from which none is excluded.

SOYBEAN AS HUMAN FOOD

Ricardo Bressani, Ph.D. [1/]

La situación mundial al presente indica que la demanda por alimentos es mayor que el abasto. En el futuro, esta realidad será más evidente, razón por la cual habrá una demanda mayor por calorías y proteínas de alta calidad, así como de otros nutrientes tales como riboflavina, vitamina A e hierro. Este trabajo discute la importancia de los productos de soya como alimento humano. Se describen los productos de soya para uso alimenticio tales como harina de soya, grano molido, concentrado de proteína (70%) y la proteína separada (90%). También se discute la calidad de la proteína y algunos resultados obtenidos en los humanos, la acción suplementaria y complementaria de los ácidos amínicos de soya con cereales y sus posibles usos para reemplazar la proteína de la carne. Finalmente se presentan trabajos relacionados con el uso de la soya en algunas comidas tradicionales de la América Latina.

I. INTRODUCTION

There is a sense of urgency around the world caused by the reality that the demand for food exceeds the supply. This reality has been more evident in recent years and will become more so in the future. Expressed in terms of nutrients, the demand calls for more calories and protein, good-quality protein, as well as for other nutrients such as riboflavin, vitamin A, and iron. Although the largest demand is in the pre-industrialized countries, the needs are also emerging in industrialized societies. The problem is becoming so difficult, in spite of the efforts done in the recent past, that more vigorous and imaginative programs are needed on the scientific, economic and social fronts.

The role of soybean as human food is very old, particularly for populations in Japan, Korea, China and others living in the Orient. However, because of food habits being what they are, it is likely that

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all of such soybean foods will not be readily adopted by other population groups.

Different approaches, or modifications of those used in the Orient, are therefore needed if soybeans are to make a nutritional contribution in other populations, and such techniques are already making head-way in countries such as the United States.

The present paper will attempt to discuss the role of soybeans as a human food or food component from a) the available soybean products which have human food applications, b) their protein quality, c) the nutritional potential of soybeans with particular reference to protein and, finally d) the use of soybean in traditional foods in Latin America.

II. SOYBEAN PRODUCTS IN FOOD APPLICATIONS

There are various soybean products, listed in Table 1, which have

TABLE 1

SOYBEAN PRODUCTS

A.	Whole soybeans
B.	Soybean flours
C.	Soybean grits
D.	Soybean protein concentrate (70% protein)
E.	Soybean protein isolate (90% protein)

a number of food applications. These depend on a number of factors which must be recognized in considering soybean products for their functional properties, such as enzyme activity, water-soluble protein, fiber and carbohydrate content, flavor, particle size, presence or absence of lecithin, and for their nutritional and economic values.

Obviously, all products are derived from whole soybeans, however, these are also used directly as human food. The next product is soybean flour, produced by solvent extraction and variable heat treatment, which will produce soy flours with different functional properties and chemical characteristics. Some soy flours are white, cooked or toasted, and others are full-fat or fat-free. Soybean flours are used in

bakery products, soybean milks, high protein foods and as protein supplements for cereal grains.

Soybean grits, obtained from defatted flakes, are very similar to soybean flour with the difference in particle size, which is coarser for grits than for flour. They are used for their water and fat absorption capacity, and one application is in meat patties. This product is relatively nexpensive and gives the desired texture to the finished food product.

Soybean protein concentrate, in contrast to the flour or grits which contain 50% protein, is a soybean product with 70% protein. It is obtained from defatted flakes after removal of the soluble carbohydrate fraction. It is used with ground meat because of its bland flavor and good functional properties. It is also used in sausage and similar products, and baby and geriatric foods. It is also being used to extend non-fat dry milk.

Finally, the soybean protein isolate is a product with not less than 90% protein, obtained from defatted flakes after alkaline extraction and isoelectric precipitation of the fraction. This product has a number of interesting functional properties which include emulsifying, fat binding, water absorption, adhesiveness, cohesiveness, film forming, thickening, suspending, stabilizing, and foaming. Its greatest use at present is in the meat industry, particularly in cooked sausage and meat loaf products. It is also used in dairy type products, dried soup mixes, infant formulations and special dietary items. The protein quality of these products has been reported by various investigators (1), and a summary of results is presented in Table 2. Protein quality tends to decrease with increasing processing as indicated by lower PER values for the isolated soy protein. All products respond to the addition of methionine, however, processing tends to damage or to alter the protein since the addition of methionine to the isolate does not increase protein quality as for soy flour or protein concentrate.

The soybean protein isolates when in alkaline dispersion give rise through special processes to the spun fibers, which are used to simulate various meat products. On the other hand, by thermo plastic extrusion process applied to soybean protein isolate or to soy flour, soybean products are being made which have applications to produce simulated meat products. This brief description indicates that at present, the soybean is already making a significant contribution into human foods and it is expected that greater and more variable applications will come in the future (1, 2, 3).

TABLE 2

PROTEIN QUALITY OF SOY PROTEIN PRODUCTS 1/

Product	Protein Efficiency Ratio	
	Without Methionine	With Methionine
Soy flour (defatted)	2.16 - 2.48	2.47
Soy protein concentrate	2.02 - 2.48	3.09 - 3.24**
Isolated soy protein	1.08 - 2.11	2.11 - 2.45**

III. PROTEIN QUALITY OF SOYBEAN PRODUCTS

The protein quality of the soybean is very well documented in experimental animals. The results of many studies are summarized in Table 3. As with most legume foods, raw soybeans reduce weight gain as well as protein efficiency ratio. However, heat processing results in all cases, when carried out under well controlled conditions, in an improvement in growth and protein quality. Many results have shown that soybean protein is deficient in sulfur-containing amino acids, and their addition results in a significant improvement in weight performance and protein quality.

Results on the quality of soybean flour protein in humans are not as available as with experimental animals; however, some results have been reported. Parthasarathy et al.(4) fed 8-9 year old children 1.2g of full-fat soybean flour protein per kg body weight per day, without and with methionine addition. The results obtained are summarized in Table 4. On soybean flour alone, average biological value, that is the amount of protein retained from that which was absorbed, was 63.5%. The addition of 1.2g of methionine per 16g of nitrogen to the soy flour increased biological value to 74.9%, equivalent to 90.6% of the biological value of skim milk protein. True protein digestibility was slightly

1/ Rakosky, Jr., J. Agr. & Food Chem. 18:1005, 1970.
* 1.0% DL-Methionine.
** 1.5% DL-Methionine.

TABLE 3

KNOWN NUTRITIONAL FACTS ON SOYBEAN PROTEIN IN EXPERIMENTAL ANIMALS

1. Raw soybean meal reduces weight gains and protein efficiency ratio (PER)

2. Weight gains and PER increase when raw soybean meal is steam-heated for as little as 15 min. Maximum values are obtained when moisted meals are autoclaved for 15 min. or for 2 hours, when autoclaved dried.

3. Growth inhibitors are destroyed by heat.

4. Protein quality increases significantly when soybean protein products are supplemented with methionine.

5. Other types of heat processing such as toasting, also destroy growth inhibitors and increase protein quality.

TABLE 4

PROTEIN QUALITY OF SOYBEAN FLOUR PROTEIN FED TO CHILDREN

Protein source	Age yrs	Protein intake g/kg/day	True protein digest. %	Biological value
Soy flour	8-9	1.2	84.0	63.5
Soy flour + DL-Met		1.2	86.4	74.9
Skim milk		1.2	87.1	82.6

Parthasarathy _et al_. _Canad. J. Biochem_. _42_:377, 1964.

lower with soybean than with milk. Graham (5) also found with children that higher nitrogen retention values were obtained with full-fat soybean flour when it was supplemented with methionine.

Fomon (6, 7) as early as 1959 studied the protein quality of soybean milk in infants. Figure 1 from his studies presents the relation of nitrogen retention to nitrogen intake. In these studies, the infants were fed pooled human milk, those fed a soybeans formula and a group fed a formula providing 7% of the calories, as protein from cow's milk. Since only one balance study was performed with the soybean formula before 121 days of age, and since the other findings were not studied after 182 days of age, the data presented are limited to the age intervals, 121-150 days and 151-182 days. On the basis of this analysis,

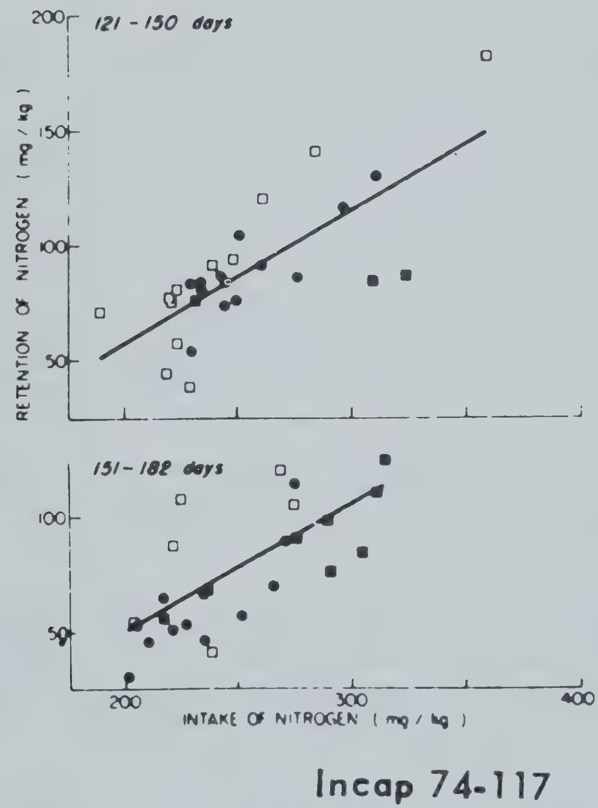


Figure 1 Regression of retention of nitrogen on intake of nitrogen for limited age ranges: 121 to 150 and 151 to 182 days. The regression lines are calculated from date pertaining to infants fed pooled human milk 1 (black dots) and formulas with protein from cow milk 3 (open squares) and soya bean 4 (solid squares).

it is concluded that under the condition of these studies, proteins from the 3 sources promote similar nitrogen retention. This suggest that the protein quality of the 3 protein foods were essentially the same. These results have been confirmed by various other authors using different soybean milk preparations (5, 8).

Older human subjects were used by Korslund et al. (9) to evaluate the quality of soybean textured protein. The results obtained by these authors are presented in Table 5. The subjects were fed 4g of nitrogen from soybean protein, as textured vegetable protein, without and with methionine supplementation, and from beef. Nitrogen balance was negative when the protein fed was TVP, in comparison with a relatively high retention from beef. However, the addition of methionine increased nitrogen retention to values higher than those from beef.

TABLE 5

QUALITY OF SOYBEAN PROTEIN IN YOUNG ADULTS

Protein source	Age yrs	Nitrogen intake g/day	Nitrogen balance g/day
Soybean protein (TVP)	12-16	4.0	-0.08
Soybean protein (TVP) + 1% DL-Methionine			+0.48
Beef			+0.32

Korslund et al. J. Food Sci. 36:841, 1971

Studies have also been carried out with adult human subjects. Kies and Fox (10) reported on nitrogen balance (results shown in Table 6) with adults fed two levels of protein from soybean protein and from beef. At the lower level of nitrogen intake, beef protein gave a better nitrogen retention than soybean textured protein without or with the addition of methionine, even though all values were negative. The

TABLE 6

QUALITY OF SOYBEAN PROTEIN IN ADULT HUMAN SUBJECTS

Protein source	Nitrogen intake g/day	Crude protein digest.	Nitrogen balance g/day
Soybean protein (TVP)	4.0	79.4	-0.70
Soybean protein (TVP) + 1% DL-Methionine		79.2	-0.45
Beef		81.4	-0.30
Soybean protein (TVP)	8.0	81.6	0.78
Soybean protein (TVP) + 1% DL-Methionine		80.1	0.72
Beef		82.7	0.74

Kies and Fox. J. Food Sci. 36:841, 1971.

addition of methionine improved nitrogen retention at the low levels of nitrogen intake but not when it increased to 8.0g/day. At this high level, all protein sources fed gave similar nitrogen retention values.

These results show that soybean protein, in its different forms, has a lower protein quality than animal protein and that it is improved when supplemented with methionine, the limiting amino acid. This information is equal to that reported from animal studies.

IV. SUPPLEMENTARY AND COMPLEMENTARY EFFECTS OF SOYBEAN PROTEIN

Soy protein contains from 60 to 105% as much of the different essential amino acids as does an equal amount of egg protein. The lowest figure, 60%, refers to the sulfur-containing aminoacids, methionine plus cystine. On the other hand, the higher value refers to lysine, amino acid deficient in most cereal grains. On these bases, the protein quality of soybeans fed alone is about average among the various food protein sources and certainly below animal derived pro-

teins. Because of the essential amino acid content in soybean protein, its greatest nutritional potential is related to the contribution it can make to balance the deficient essential amino acid composition of cereal grains. These latter foods, as is well known, provide for many population groups the largest intake of protein.

The role soybean protein can make in this respect is two fold. One, as supplementary protein to cereal grains, and two, as the main protein component in high protein foods. The role as supplementary protein is well documented and some results (11, 12, 13) are presented in Table 7. Analysis of these results show two points of interest. One

TABLE 7

EFFECT OF SOYBEAN FLOUR AS A PROTEIN SUPPLEMENT TO CEREAL GRAINS

Cereal grain	Level of soybean %	Protein Efficiency Ratio	Additional protein from soybean, g
Maize	-	1.00	4
Maize + SBF	8.0	2.25	
Rice	-	1.87	4
Rice + SBF	8.0	2.88	
Wheat flour	-	0.70	5
Wheat flour + SBF	10.0	2.01	
Whole wheat	-	1.32	5
Whole wheat + SBF	8.0	1.91	

is that the addition of relatively small amounts of soybean flour increase the protein quality of the cereal grain, and second, that total protein is also increased in amounts 4 to 5g above what the cereal

contains. Practical applications of these results are already being made but most of them in the developed countries.

Based on the results shown, a protein supplement for maize flour for tortilla preparation was developed in our laboratories a few years ago (14). The formula for this supplement is shown in Table 8, and it

TABLE 8

SOYBEAN FLOUR SUPPLEMENT FOR LIME-TREATED MAIZE

Ingredient	Composition of the supplement, %
Soya flour	97.5000
L-Lysine HCl	1.5000
Thiamine	0.0268
Riboflavin	0.0162
Niacinamide	0.1930
Ferric orthophosphate	0.6000
Vitamin A 250 SD	0.0313
Corn starch	0.1327
	100.0000
Rate of addition	8%

contains soybean flour, lysine, thiamine, riboflavin, niacin, vitamin A and iron. This supplement can be added to lime-cooked industrial maize flours or at the time cooked maize is being ground at the village level, at the rate of 8%. Its acceptance and long-term effect is currently under study in Guatemala, in a village with 1700 families (15).

TABLE 9

AVERAGE NITROGEN BALANCE IN PRESCHOOL AGE CHILDREN RECEIVING MAIZE AND MAIZE PLUS SOYBEAN SUPPLEMENT

Protein source	Chronological age months	Protein intake g/kg/day	Intake	Nitrogen Balance		No. of children
				Absorbed	Retained	
			mg/kg/day			
Maize	30	1.25	192	144	30	6
Maize + Soy supplement	30	1.25	197	154	63	6
Milk	24	1.25	195	157	75	7

The protein quality improvement caused by the addition of the supplement can be seen in Table 9 as tested in children (16). Intake of protein was fixed at 1.25g/kg/day with an adequate intake of calories, 100 per kg/day. As seen in the nitrogen retained column, the 8% addition of the supplement increased retention to values close to those obtained from milk. Other applications have been shown in recent years. One of much importance is the use of soybean flour, fat-free or full-fat, to make bread. The results of Tsen and Hoover (17, 18) are shown in Table 10. Bread made with 12% soybean flour not only are acceptable

TABLE 10

PROTEIN QUALITY OF BREAD WITHOUT AND WITH SOYBEAN FLOUR*

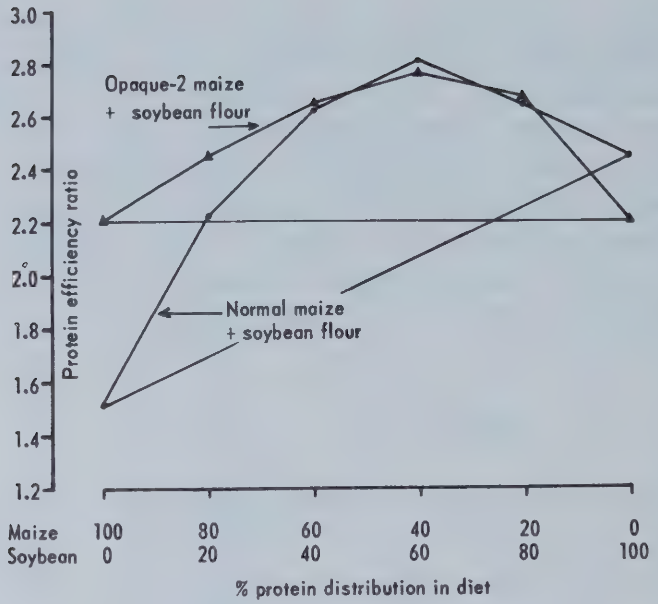
Bread	Moisture %	Protein %	Gain, g**	gain, g/ protein consumed
White	9.5	14.0	32	0.92
12% soy	9.2	18.3	120	1.55

by the consumer, but contain more protein of a better quality than common wheat flour bread.

As indicated before, the second important role soybean can make, in terms of nutrition, is as the main protein component in high protein containing foods. The complementary effect of soybean protein with that of common and opaque-2 maize is shown in Figure 2 (19). Maximum protein quality is obtained when either type of maize contributes 40% of the dietary protein and soybeans 60%. For a high protein food containing 18% protein, 7.2g should be derived from maize and 10.8 from soy flour. In terms of weight, these values would be

* Cho, C. Tsen. Proceso para Mejorar el valor proteínico del bolillo. Consejo Nacional de Ciencia y Tecnología Julio, 1972.

** Diet. 91.5% ground bread + 2.0% vitamin premix + 2.0% mineral premix + 3.0% fat.



	Lys	Try	T.S.A.A.
	mg/g N		
Normal maize	180	38	197
Opaque-2 maize	306	94	234
Soybean flour	395	86	195

Incap 72-1366

Figure 2 Protein efficiency ratio of combination of normal or opaque-2 maize and soybean flour.

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equivalent to about 80g of maize and 20g of soy flour. Mixtures of this kind are already being produced either for world distribution, such as corn-soy-milk, wheat-soy blend, or locally produced as, for example, INCAP Mixture 14 (20, 21, 22, 23). Representative results of the evaluation in children of two high protein foods developed in Latin America are shown in Table 11. Mixture 14 (20) containing 38% soybean flour and the Infant food (24) with 19.5% soybean flour and 4.5% non-fat milk, although their protein digestibility was below that of milk protein. These mixtures, if kept at low economic levels, are very useful nutritionally and represent an efficient way to use soybeans as human food.

V. SOYBEANS AS HUMAN FOODS IN DEVELOPED COUNTRIES

Soybean textured foods offer many possibilities for the nutrition of humans, because of their adaptability to different forms of organoleptically good and economical products. Because of the particular

TABLE 11

NITROGEN BALANCE IN CHILDREN FED HIGH PROTEIN FOODS CONTAINING SOYBEAN FLOUR

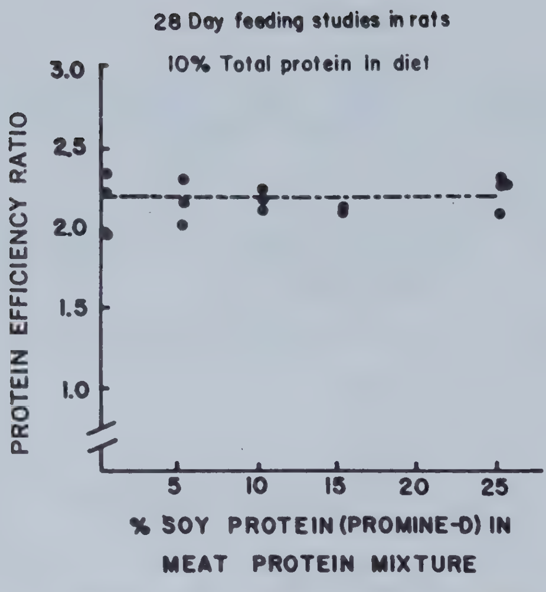
Protein food	Protein intake g/kg/day	Absorption % of intake	Retention % of intake
Mixture 14*	2.17	75.5	27.1
Milk	2.41	88.6	21.5
Infant food**	1.98	72.7	23.8
Milk	2.38	80.1	30.3

characteristics of soybean protein, this is finding greater applications in the food industry, and it represents probably the greatest contribution soybean protein will make as human food. Texture is obtained in two ways: a) by way of a fiber spinning process or b) by thermoplastic extrusion. Both types of products are being used to replace part of the meat or to make simulated meat analogues (1, 2, 3).

The nutritional value of the thermo-plastic extruded product has been tested with young and adult human subjects, and results obtained by Kies and Fox (10) and Korslund et al. (9) have already been presented. These products can replace meat protein up to a certain point without decreasing the quality of the mixture. As shown in Figure 3, meat protein was replaced by soybean protein up to 25%. The possible changes in protein quality were measured by the protein efficiency ratio method. As the results indicate, up to the 25% level of replacement, there was no change in protein quality. These results demonstrate a way to extend meat supplies by soybean protein, and to make available food products of high nutritional value and possibly low in price (1).

Simulated beef products made from soybean protein fiber have also been tested for their protein quality. These products contain, along with the soybean protein, other food components such as vege-

* Bressani et al. Arch. Latnoamer. Nutr. 22:227, 1972.
** Dutra de Oliveira et al. J. Food Sci. 32:131, 1967.



Nutritional value of meat protein–soy protein mixtures (Meyer, 1966). From: ***Proc. Int. Conf. Soybean Prot. Foods*** **(1966)**

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Figure 3 Nutritional value of meat protein-soy protein mixtures (Meyer, 1966). From Proc. Int. Conf. Soybean Prot. Foods (1966).

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table fat, egg albumin, wheat gluten, soybean meal, vegetable protein hydrolysate and various additives; therefore, the nutritional value is man-controlled. In a study reported by Bressani et al.(25), a simulated beef granule was tested in experimental animals and children. The soy protein isolate, the spun fibers and the textured food made from them were assayed for their protein quality. Table 12 summarizes the results. As the material was converted from isolated protein to textured food, protein quality improved, effect attributed to the use of heat. This is confirmed by the results in the second two columns where heating increased weight grain and protein quality of each preparation. The effect of the other proteins added to the fibers is responsible for the significant increase in weight gain and PER observed (25). Results with children are presented in Table 13. Protein intake from both sources was set at 2g/kg/day, and the values shown represent the average for 8 children. The nitrogen retention figures obtained suggest that at this particular level or protein intake, both protein sources have similar quality. Additional tests indicated, however, that the biologic value of the simulated beef granule was 70.8% in comparison with a value of 80.6% for milk. The authors concluded that the protein quality of the granule was high, 80% that of milk, with adequate digestibility, acceptable and free of adverse physiological effects.

TABLE 12

PROTEIN QUALITY OF SOY PROTEIN ISOLATE, FIBER AND SOY TEXTURED FOOD

Soy protein	As received		Heat treated	
	Ave. Wt. gain, g	P.E.R.	Ave. Wt. gain, g	P.E.R.
Isolate	-5	-	81	2.44
Fiber	59	1.88	72	2.23
Textured food	98	3.30	138	3.38
Casein	118	3.53	-	-

Bressani et al. J. Nutr. 93:349, 1967.

The protein quality of a soya-meat was evaluated by Turk et al. (26) in adults, and the results were reported recently. The authors indicated that with adults, positive nitrogen balances were observed with intakes of 0.258g of protein per kilogram per day and below. These results suggest, therefore, that the protein quality of the soya-meat products is as high as that of egg (27).

These results indicate that the protein quality of soyameat containing products is different depending on the manner in which soybean protein is used. Those based on soybean textured protein with flavor added are lower in quality than those in which the textured protein is mixed with other protein sources. However, the first may be improved by methionine supplementation or consumed together with other foods rich in this amino acid.

VI. USE OF SOYBEANS IN TRADITIONAL FOODS FOR LATIN AMERICA

The results of various studies have indicated that the diets consumed by children and even by adults in developing countries are not

TABLE 13

NITROGEN BALANCE OF CHILDREN FED MILK AND SOYBEAN SIMULATED BEEF GRANULES

Protein source	Intake	Nitrogen Balance Fecal	Urine	Absorbed	Retained	Absorption	Retention
	mg/kg/day					% of intake	
Milk	342	52	210	290	80	84.8	23.4
Simulated beef granules	312	46	183	266	82	85.2	26.6

Bressani *et al*. *J. Nutr*. *93*:349, 1967

only deficient in quantity and quality or protein, but in calories as well. When these diets are supplemented with calories, their protein quality is increased as shown in the nitrogen balance results of Figure 4.

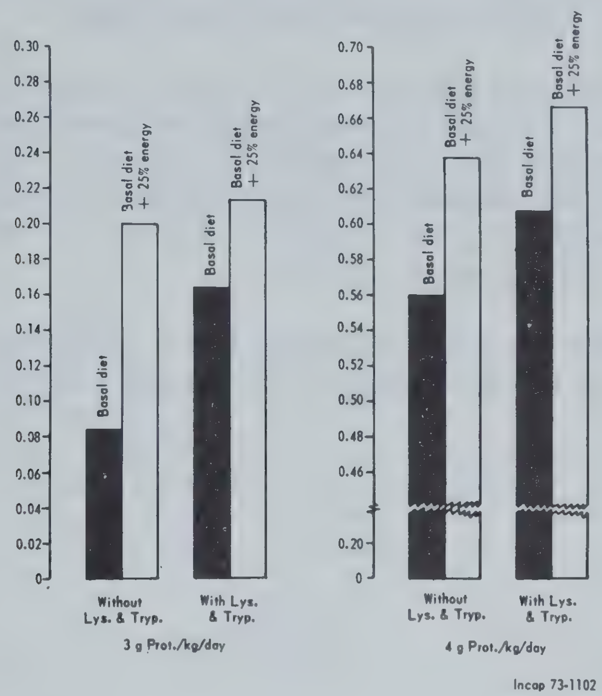


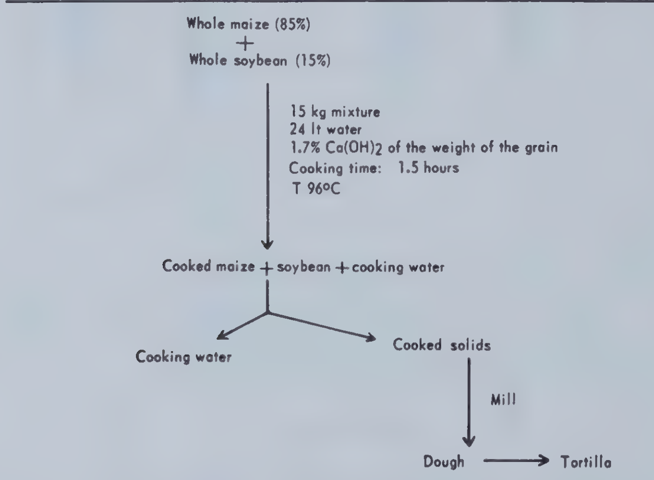
Figure 4 Effect of adding lysine and tryptophan to a maize-black bean diet with and without additional energy.

In this study, using small dogs as experimental animals (28), the maize-bean diet in a ratio of 6.24 to 1 was supplemented with 25% additional calories added as soybean oil, or supplemented with lysine and tryptophan, or both. The treatments were studied at 3 and 4g of protein intake per kg body weight per day. The bars indicate the extent of the improvement, and it can be seen that calorie addition induced as good an improvement as the addition of amino acids, which are limiting the quality of the protein fed. These results suggest that under ordinary conditions the protein ingested is used as an energy source; however, when it is provided as a supplement to the diet, the protein ingested is used for purposes of body protein synthesis. That protein quality is important also is shown by the response to the amino acid supplements added. Finally, total protein intake is also limiting, since nitrogen balance results are higher when the animals consumed 4g of protein than when intake was 3.0g. The practical solution of this problem is not easy. First of all, additional intake of calories and protein can not be increased much from the same basic food stuffs,

maize and beans, because the amounts would be too large and bulky, and secondly, because of the cost. This approach furthermore, will not correct the protein quality aspect. Correction of the calorie deficit by consumption of oil, although sound, is not possible because of cost. Therefore, other solutions should be found.

A possibility under study in our laboratories is through the use of the whole soybean. As has already been indicated, soybean is not only a good protein source, but it contains oil as well. In our laboratories, the use of the whole soybean has been studied in the production of at least two types of foods, the tortilla made from maize, and a high protein food also based on maize (29).

The production scheme of tortillas from maize and whole soybeans is shown in Figure 5. A mixture of 85% maize and 15% whole soybeans



Soybean: harvested at INCAP Experimental Farm (14.0% fat, 30% protein).
Yellow maize: Azotea variety, harvested at INCAP Experimental Farm (8% protein).

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Figure 5 Tortilla preparation from maize and whole soybeans.

are cooked together as shown. The level of 15% soybeans was used because of previous results using 8% soybean flour. Both levels provide similar amounts of protein. The product is quite similar to the common tortilla, however, it is of superior protein content and quality. These materials have been assayed for their protein quality and representative results are shown in Table 14.

TABLE 14

PROTEIN QUALITY OF TORTILLA FLOUR ALONE AND SUPPLEMENTED WITH WHOLE SOYBEANS

	Content in products protein %	fat	Ave. Wt. gain, g	P.E.R.
Tortilla flour 1/	10.0	3.0	18	0.95
85% tortilla flour + 15% soybean flour 2/	13.9	5.5	84	1.98
92% tortilla flour + 8% soybean flour 2/	13.2	2.8	68	1.98
85% tortilla flour + 15% soybean flour 2,3/	13.9	5.5	78	1.98
Casein 2/	-	-	124	2.60

The results clearly show improved quality when the tortilla was made with 15% whole soybeans. What is of interest is that the tortilla contains additional oil which provides more calories, and these are effective in making better use of the protein as indicated in the last group shown in the Table.

The second type of product tested so far is one containing higher levels of protein and fat derived from soybeans. To learn which combination was nutritionally superior, various maize and whole soybean mixtures were processed as shown in Figure 6. This processing scheme is equal to the one used for tortillas. Previous studies suggested the optimum level of lime to be used is the one shown in the Figure. It was also found that as the level of soybeans in the mixture

1/ Diet contained 9.0% protein.
2/ Diet contained 12.3% protein.
3/ Was not supplemented with 5% oil.

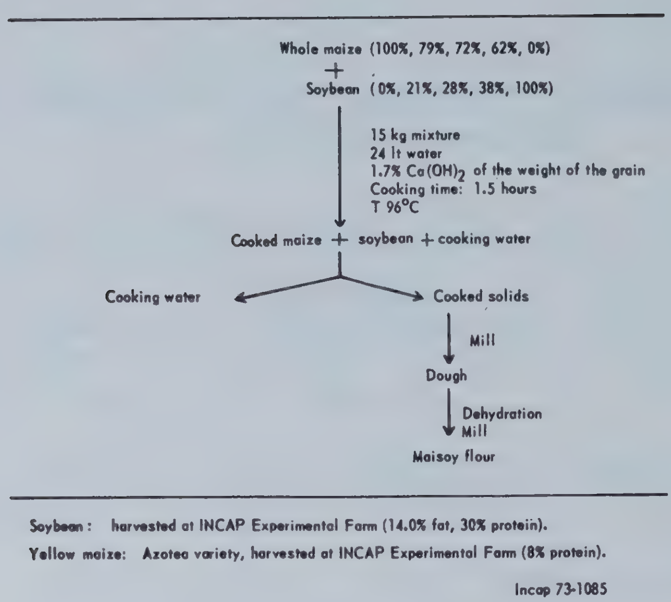

Figure 6 Processing of mixtures of maize and soybean.

exceeded 40%, recovery of solids also decreased. This was interpreted as loss of protein and other compounds due to the alkaline cooking conditions used.

The products obtained were dried, ground, analyzed and assayed for protein quality. The results are summarized in Table 15. The protein quality column indicates that the combination giving maximum protein quality is the one based on 72% maize and 28% whole soybeans (29). This product contains close to 18% protein and 10.0% fat, therefore, is a high protein calorie food which could be a good supplement to the diets already consumed by many people in Latin America and other parts of the world. The value of soybeans as a human food has been demonstrated for many years in the oriental countries, and food science and technology is increasing its potential as a calorie and protein source for present and future populations of the world. Basic to all this is the role agronomy can do to make it possible to grow soybeans efficiently in areas where up to now its cultivation has not been successfully possible.

TABLE 15

PROTEIN AND FAT CONTENT AND PROTEIN VALUE OF MAIZE-WHOLE SOYBEAN MIXTURES

Mixture		Content of		
Maize %	Soybean %	Protein %	Fat %	P. E. R.
100	0	9.9	4.5	0.69
79	21	16.9	8.9	2.08
72	28	17.6	10.3	2.54
62	38	18.1	11.3	2.37
0	100	40.0	25.6	2.03
Casein		-	-	2.87

Bressani et al. J. Food Sci. 1974

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VIII. FIGURES AND TABLES

Legends to Figures

Figure 1 Regression of retention of nitrogen on intake of nitrogen for limited age ranges. 121 to 150 and 151 to 182 days. The regression lines are calculated from data pertaining to infants fed pooled human milk 1 (black dots) and formulas with protein from cow milk 3 (open squares) and soya bean 4 (solid squares).

Figure 2	Protein efficiency ratio of combination of normal or opaque-2 maize and soybean flour.
Figure 3	Nutritional value of meat protein-soy protein mixtures (Meyer, 1966). From Proc. Int. Conf. Soybean Prot. Foods (1966).
Figure 4	Effect of adding lysine and tryptophan to a maize-black bean diet witn and without additional energy.
Figure 5	Tortilla preparation from maize and whole soybeans.
Figure 6	Processing of mixtures of maize and soybean.

FOODS FROM WHOLE SOYBEANS

A. I. Nelson and L. K. Ferrier 1/

Las habichuelas soyas son una excelente fuente de nutrientes. El material seco de la soya contiene alrededor de 40% de proteína y 20% de grasa. Los aminoácidos de ésta se acercan al contenido de las recomendaciones óptimas de la FAO y la grasa tiene cantidad considerable de ácidos grasos no saturados. Adicionalmente es una buena fuente de vitaminas y minerales.

Algunos de los productos alimenticios de la soya preparados en la Universidad de Illinois son: hojuelas de soya o en combinación, habichuelas soyas enlatadas, bebidas de soya y productos derivados, unturas, y piscolabis.

The soybean is an excellent source of nutrients. About 40 percent of the dry matter in the soybean is protein and it also contains about 20 percent fat. The amino acid pattern of soy protein approaches the optimum FAO recommendation and the oil is quite desirable because it contains considerable unsaturated fatty acids. In addition, soybeans appear to be a good source of a number of the required vitamins and minerals. Thus, the soybean has great potential for people who rely mostly upon vegétable sources for protein.

Nearly all of the soybeans produced in the U. S. A. and Brazil are processed in oil extraction plants. The oil is generally needed for mayonnaise, salad dressing and margarine the world over, and the extracted flake, which contains about 50 percent protein, is used mainly as protein supplements for animal feed. However, human food uses of extracted flake are increasing rapidly. Some of the products which are processed for human food from extracted flakes include soy protein concentrates, isolated soy protein, textured vegetable protein and soy protein meat analogs.

Another potential benefit is the direct use of whole soybeans with the oil content intact, for preparing foods for home use and for commercial processing. The Department of Food Science, at the University of Illinois, has developed procedures for processing whole soybeans into a number of products which appear to have real potential (1,

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2, 3). The processing procedure is straightforward and uncomplicated. Basically, all of the processes start with field dried soybeans and foreign material. At this point, the beans are hydrated by soaking in tap water for about five to twelve hours followed by precooking (blanching) in boiling water for about 20-30 minutes. For products which require tender blanched beans, 0.5% $NaHCO_3$ is added to the blanch water. Products which do not require exceptionally tender beans can be hydrated and blanched in one operation which requires at least 20 minutes. After blanching, the beans are bland in taste and chewy to tender in texture, depending upon the methods followed in rehydration and blanching.

The success of this process is directly related to inactivation of enzymes, principally the lipoxygenase enzyme system in the raw soybean before the tissue is disrupted. When the raw tissue is broken, the enzyme and the substrate (oil) are liberated and, provided some moisture is present, a bitter, beany taste instantaneously develops. However, the enzyme system is inactivated if the whole soybean is first hydrated and blanched in boiling water. This blanching simultaneously destroys the trypsin inhibitor and hemaglutinins present in raw beans; if present, these inhibitors would substantially reduce the nutritional quality of the soybeans by inhibiting trypsin and other digestive enzymes. The length of time required to destroy these components decreases with increased moisture content of the soybeans. For example, trypsin inhibitors can be destroyed in rehydrated beans (containing 50 to 60 percent moisture) by boiling for five minutes. However, if dry soybeans are used, they must be boiled for 20 minutes to destroy trypsin inhibitors. Lipoxygenase is inactivated in rehydrated soybeans by boiling for less than five minutes.

Boiling is also essential to produce an acceptable texture and, for practical purposes, the desired texture will dictate the boiling time required. Tenderization is faster at higher pH levels. Use of softened water (pH 7.5) or a 0.5 percent solution of sodium bicarbonate (pH 7.9) results in much more rapid tenderization and sharply reduces required cooking time (1). Soaking and boiling also removes about one-third of the oligosaccharides in soybeans, some of which are believed responsible for the production of flatus. Only a small amount of the protein (1% of the Kjeldahl nitrogen) is lost during soaking and blanching.

As mentioned earlier, when the tissue of the soybean cotyledon is disrupted or damaged and moisture is present, the characteristic "beany" or "painty" off-flavor develops. In University of Illinois tests, drum dried products were prepared using 0, 25, 50, 75 and 100 percent slightly damaged soybeans. Taste panels could easily detect the beany off-flavor when 25 percent slightly damaged soybeans were processed by the Illinois process, although the flavor difference was not pro-

nounced. If hull damage is greater than 15 to 20 percent, blanching before soaking is recommended.

Properly hydrated and blanched soybeans offer great potential for processing into a wide variety of food products (1, 6). Some of the foods which were made at the University of Illinois are listed in Table 1. Each category will be discussed briefly.

Category I. Drum Dried Flakes

1. 100% Whole Soybean
2. Soy-Rice (50:50)
3. Soy-Corn (50:50)
4. Soy-Brown Sugar-Peanut (50:35:15)
5. Soy-Banana (50:50) Weaning Food

Category II. Canned and Homecooked Soybeans

1. Vegetarian soybean
2. Three bean salad
3. Soy with chicken
4. Soy with pork
5. Soy with lamb
6. Pork with soybeans

Category III. Soy Beverages and Beverage Products

1. Beverage, plain
2. Beverage, chocolate flavored
3. Blend of soy beverage and cottage cheese whey
4. Ice cream, mocha flavor
5. Yogurt

Category IV. Spreads

1. Diet spread, margarine flavor
2. Dip
3. Peanut butter analog

Category V. Snacks

1. Roasted soybean cotyledons
2. Extruded, puffed rice and corn fortified with full fat soy flour

Category I. Drum Dried Flakes

The drum dried flakes are made by preparing a slurry of the cooked soybeans in water and drum drying the slurry. If the final product contains other materials such as fruit or cereals, these are mixed in the soybean slurry and the combination is drum dried. These flakes may be used directly as a weaning food or they may be mixed into other foods such as baked goods to increase the protein content. Mixtures of soybeans and cereals, such as corn or rice, should improve the essential amino acid profile since cereals are typically low in lysine and adequate in methionine, whereas legumes, such as soybeans, are normally the reverse, that is, low in methionine and adequate in lysine.

Soybean-fruit mixtures have potential because the flavor of the fruit is dominant in the dried flakes but the increased protein and calorie content of the soybean is present. A 1:1 soybean:banana flake was prepared as described earlier (5). The best product resulted when very ripe bananas were used. This product is very stable and contains a good mixture of the major nutrients, -viz 23% protein, 9% oil and 50% carbohydrate. This product was found to be low in methionine but the deficiency can be corrected by addition of methionine or by adding corn to the formula as mentioned in the earlier worshop paper by Dr. Bressani. This product should provide a tasty nutritious weaning food as is. This also provides a useful method for using very ripe bananas which would otherwise be discarded.

Category II. Canned and Homecooked Soybeans.

The concept for hydration and blanching of whole soybeans offers potential for home utilization of whole soybeans. Recipes for preparation of soybeans for home use have been developed and are available from a number of countries, for example, that by Dr. Van Duyne in the Department of Home Economics at the University of Illinois (7,8). We believe that the principles involved in hydration and blanching would improve some foods in which the recipes call for procedures that allow some enzyme activity before blanching or cooking.

We have made use of a number of recipes to prepare canned soybeans having a variety of flavors (Table 1). Standard bean processing procedures were used to can these products except that the soybeans were presoaked in weak $NaHCO_3$ solution rather than tap water. (3)

Category III. Soy Beverages and Beverage Products

A simple process was developed at the University of Illinois which allows use of blanched soybeans to produce a stable soy milk (no beany

flavor [6]). The whole soybean is used and the soy milk contains as much as 3.6 percent protein (depending on dilution), equivalent to that in cow's milk and nearly twice as much as the soy milk currently marketed or manufactured by the traditional process. Essentially 100 percent of the protein and 95 percent of other constituents are recovered from the bean. The only losses occur during blanching and these losses are desirable with respect to reducing flatus. Basically the beverages are prepared by grinding the cooked soybeans with water, adding sucrose and flavoring, homogenizing and pasteurizing.

The major disadvantage is the necessity of homogenization in order to produce a stable suspension. Thus, it is not a home or village scale process. The major advantages compared to the traditional soy milk are an excellent mild flavor, no off-flavor, destruction of antinutritional factors and increased protein content. A University of Illinois patent application covers the preparation of the soybean beverage base. (6) The beverage has been used to replace milk in products such as soy ice cream, soy yogurt custard and diet margarine, all of which are prepared by conventional methods.

Category IV. Spreads

Spreads or intermediate moisture foods constitute another group. An excellent diet margarine was prepared following conventional methods but using soy beverage instead of milk solids. A very acceptable chip dip can be prepared simply by changing the flavorings used. Roasted soybean cotyledons plus added soybean oil can be processed using a colloid mill into a "soybean butter," which resembles peanut butter in character and flavor.

Category V. Snacks

Soybeans can be roasted to make a dry nut similar to peanuts. First the blanched soybeans should be dehulled using a disc (Buhr) mill or similar mill. At home dehulling can be done by rubbing small handfulls between the hands. Rinse with water to remove the hulls and fines. After draining the cotyledons are deep fried in oil at about 190°C for two and a half minutes. They may be roasted at home in a frying pan with a little oil but the roasting time will be longer. If the hulls are left on, the roasting time is longer. Salt or other flavorings should be added while the beans are still hot.

Extruded puffed snack foods have also been prepared using a Wenger extruder. The feed flour contains about 20 percent full fat soy flour and 80 percent corn or rice flour. After addition of oil and flavoring (as is usually done to this type of snack), the protein content is at least 3 g/100 calories.

We believe that tasty snacks provide an avenue for introducing soy food to people who would normally resist trying any unfamiliar food.

These few examples illustrate the wide variety of tasty and nutritious foods which can be manufactured from a single starting material, the cooked, whole soybean. We believe that those and other soybean products can be adapted to fit the taste and texture preferences of people throughout the world.

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WRAP-UP DISCUSSION OF FOOD USES

G. K. Parman 1/

This has been an interesting and, I hope, a stimulating workshop. Being the last speaker on the program, I am going to comment somewhat more broadly on the program than my subject indicates.

We at AID are interested in helping the poor in the developing countries. This covers the small farmer and the rural and urban poor. All of our research efforts and the bulk of our development program in the developing countries are aimed at this goal. The large farmers, nearly everywhere, have access to and can buy advice and inputs. The small farmer can't. I was pleased to hear, therefore, Dr. Camacho so eloquently stress the peculiar problems of the small farmer in terms of marketing. It is a point that must be adhered to if we are really to help the small farmer in an effective way.

I stressed earlier, and I will repeat, that we must begin to think in terms of production with limited inputs because the agricultural chemical inputs that have helped attain high yields in the past are going to be the developing countries and elsewhere. All of our ingenuity will be required to develop varieties that have innate resistance to insects and disease and can produce reasonable yields under favorable conditions.

With regard to utilization, we have heard some excellent presentations. Dr. Bressani gave a well-organized and well-presented overall view of the nutritional aspects of soybeans and there is little that one can add to his presentation. Our friends from the University of Illinois have very clearly shown you, I think, that soybeans are really an attractive food. I am always surprised, and even amused, to see what a surprise it is to so many people that soybean foods are really good. The "chow line" in front of the sample table was an eloquent testimony to the high acceptability of soybean foods. It is too bad we weren't able to serve the soybean ice cream, it is really an outstanding product. The important thing to remember, however, is that many of these products can be made in the home, or through village scale processes. Large and complicated installations are not needed so that many of these

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products can be the nucleus for small rural industries with an output commensurate with the market.

The capability of production on small scale is important. Nearly all work done on soybean foods in the U.S.A. has entailed the use of solvent extracted soybean meal as a raw material. This is all right if you have a market for a lot of meal and can obtain a lot of soybeans because the minimum economic size for a solvent extraction plant continues to get larger and larger. Currently, I would estimate that the minimum economic solvent plant size is no less than 300 tons of input per day, which is 60,000 tons of beans per year on a minimum 200-day work year, which is a lot of beans and a lot of meal, not to mention a very substantial capital investment. By contrast, the Illinois processes can be conducted at pounds or few tons per day. Processes for producing full fat soy flours for food or feed use are being developed by Buhler Brothers in Switzerland and by Dr. Hudson at Colorado State. The former uses a fluid bed drier for the critical heating step, the latter uses hot salt crystals in the source proposed. Both can be operated economically on low production rates and do not involve large investments or the problems of obtaining solvents of acceptable purity etc. The use of such full fat flours in foods and feeds offers real opportunities to effectively and rapidly increase the nutritive value of a national diet and to provide additional revenue for the farmer and the processor, and increased employment and better nutrition for the consumer.

On behalf of AID, I wish to thank the speakers for good and stimulating papers and the audience for good and stimulating discussions. We can all look forward to receiving the proceedings which will be, I think, a good contribution to the scientific literature.

ATTENDANCE TO THE WORKSHOP ON SOYBEANS FOR TROPICAL AND SUBTROPICAL CONDITIONS

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